



Safety

**OPERATIONAL RISK MANAGEMENT (ORM)
GUIDELINES AND TOOLS**

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OPR: HQ AFSC/SEPR (Mr John D. Phillips)
Supersedes AFPAM 91-214, 1 September 1997.

Certified by: HQ AFSC/SEP (Col Roger C. Craig)
Pages: 114
Distribution: F

This pamphlet is the process guide for the US Air Force Operational Risk Management (ORM) Program as prescribed by AFI 91-213, *Operational Risk Management (ORM) Program*. This pamphlet provides the definitions, guidelines, procedures and tools for the integration and execution of ORM. It has application and use for all US Air Force organizations and personnel.

SUMMARY OF REVISIONS

This document is substantially revised and must be completely reviewed.

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Section A—Key ORM Concepts

1. Introduction. All US Air Force missions and our daily routines involve risk. All operations, both on- and off-duty, require decisions that include risk assessment as well as risk management. Each commander and supervisor, along with every individual, is responsible for identifying potential risks and adjusting or compensating appropriately. Risk decisions must be made at a level of responsibility that corresponds to the degree of risk, taking into consideration the significance of the mission and the timeliness of the required decision. Risk should be identified using the same disciplined, organized, and logical thought processes that govern all other aspects of military endeavors. The USAF aim is to increase mission success while reducing the risk to personnel and resources to the lowest practical level in both on- and off-duty environments.

1.1. Risk management is an essential element of military doctrine. Uncertainty and risk are part of all military operations. A time-tested principle of success in the United States Air Force and joint operations is taking bold, decisive action, and a willingness to identify and control or accept the associated risk. Risk is the probability and severity of failure or loss from exposure to various hazards. Carefully determining the hazards, analyzing and controlling the hazards, and executing a supervised plan that accounts for these hazards contributes to the success of the application of military force.

1.2. Risk management is the process used by decisionmakers to reduce or offset risk. The risk management process provides leaders and individuals a systematic mechanism to identify and choose the optimum course of action for any given situation. Risk management must become a fully integrated element of planning and executing an operation. The ORM process is applicable to all levels of military operations from strategic to tactical. Commanders are responsible for the routine application of risk management in the planning and execution phases of all missions, whether they are combat or support operations.

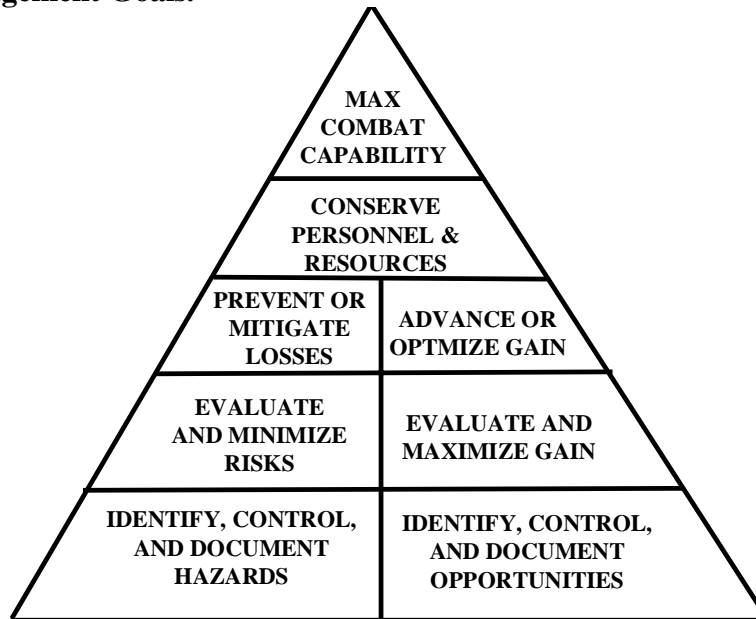
1.3. Risk management is not a radical new way of doing business; the USAF has been applying risk management philosophy and methods intuitively and experientially for years. The record low mishap rates in the ground, flight, weapons and space arenas are the result of these risk management efforts. However, ORM provides a process that will allow greater and more consistent results by using a systematic method rather than relying solely on experience. The cornerstone of this program is early education of USAF personnel in risk management principles and tools.

2. Vision. Create an Air Force in which every leader, airman and employee is trained and motivated to personally manage risk in all they do, on- and off-duty, with the objective of continuously widening the gap between what the Air Force can do in battle and what its adversaries can do, ensuring decisive victory in any future conflict at the least possible cost.

3. Goals and Objectives. The ultimate objective of any organization within the Air Force is maximizing combat capability. Important elements in this objective are protecting our personnel and conserving combat weapon systems and their support equipment. Preventing mishaps and reducing losses is an important aspect of conserving these resources. Risk management contributes to mishap prevention and therefore to combat capability by minimizing risks due to hazards consistent with other cost, schedule, and mission requirements. The fundamental goal of risk management is to enhance mission effectiveness at all

levels while preserving assets and safeguarding health and welfare. Beyond reducing losses, risk management also provides a logical process to identify and exploit opportunities that provide the greatest return on our investment of time, dollars and personnel. This hierarchy of goals, illustrated in Figure 1, is the crucial framework for defining risk management.

Figure 1. Risk Management Goals.



4. Principles. Four principles govern all actions associated with risk management. These continuously employed principles are applicable before, during and after all tasks and operations.

4.1. Accept no Unnecessary Risk. Unnecessary risk comes without a commensurate return in terms of real benefits or available opportunities. All US Air Force missions and our daily routines involve risk. All activities require a basic understanding of hazards and risks as well as appropriate controls. The most logical choices for accomplishing a mission are those that meet all mission requirements while exposing personnel and resources to the lowest acceptable risk. ORM provides tools to determine which risk or what level of risk is unnecessary. The corollary to this axiom is “accept necessary risk” required to successfully complete the mission or task. As an example, choosing the lowest threat ingress to a target versus the most direct route avoids unnecessary risk.

4.2. Make Risk Decisions at the Appropriate Level. Making risk decisions at the appropriate level establishes clear accountability. Those accountable for the success or failure of the mission must be included in the risk decision process. Anyone can make a risk decision; however, the appropriate level for risk decisions is the one that can allocate the resources to reduce the risk or eliminate the hazard and implement controls. Commanders at all levels must ensure subordinates know how much risk they can accept and when they must elevate the decision to a higher level. Typically, the commander, leader, or individual responsible for executing the mission or task is:

4.2.1. Authorized to accept levels of risk typical of the planned operation (i.e., loss of mission effectiveness, normal wear and tear on materiel).

4.2.2. Required to elevate decisions to the next level in the chain of command after it is determined that controls available to him/her will not reduce residual risk to an acceptable level.

4.3. **Accept Risk When Benefits Outweigh the Costs.** All identified benefits should be compared to all identified costs. The process of weighing risks against opportunities and benefits helps to maximize unit capability. Even high risk endeavors may be undertaken when there is clear knowledge that the sum of the benefits exceeds the sum of the costs. Balancing costs and benefits may be a subjective process and open to interpretation. Ultimately, the balance may have to be determined by the appropriate decision authority.

4.4. **Integrate ORM into Air Force Doctrine and Planning at all Levels.** To effectively apply risk management, commanders must dedicate time and resources to incorporate risk management principles into the planning processes. Risks are more easily assessed and managed in the planning stages of an operation. Integrating risk management into planning as early as possible provides the decision maker the greatest opportunity to apply ORM principles. Additionally, feedback must be provided to benefit future missions/activities.

Section B—The ORM Process

5. Introduction. ORM is a continuous process designed to detect, assess, and control risk while enhancing performance and maximizing combat capabilities. ORM provides the basic structure for the detection, assessment, and ultimate sustained control of risk while enhancing performance and maximizing combat capabilities. Individuals at all levels, identify and control hazards through the ORM process. Figure 2 shows the ORM process chart with its six steps. Note: When interfacing with an organization that uses a five-step method, keep in mind that they have taken steps 3 and 4 of the basic Air Force process and combined them into one step in their programs.

Figure 2. Six-Step Process of Operational Risk Management.



5.1. Identify the Hazard. A hazard can be defined as any real or potential condition that can cause mission degradation, injury, illness, death to personnel or damage to or loss of equipment or property. Experience, common sense, and specific risk management tools help identify real or potential hazards.

5.2. Assess the Risk. Risk is the probability and severity of loss from exposure to the hazard. The assessment step is the application of quantitative or qualitative measures to determine the level of risk associated with a specific hazard. This process defines the probability and severity of a mishap that could result from the hazard based upon the exposure of personnel or assets to that hazard.

5.3. Analyze Risk Control Measures. Investigate specific strategies and tools that reduce, mitigate, or eliminate the risk. Effective control measures reduce or eliminate one of the three components (probability, severity, or exposure) of risk.

5.4. Make Control Decisions. Decision makers at the appropriate level choose the best control or combination of controls based on the analysis of overall costs and benefits.

5.5. **Implement Risk Controls.** Once control strategies have been selected, an implementation strategy needs to be developed and then applied by management and the work force. Implementation requires commitment of time and resources.

5.6. **Supervise and Review.** Risk management is a process that continues throughout the life cycle of the system, mission, or activity. Leaders at every level must fulfill their respective roles in assuring controls are sustained over time. Once controls are in place, the process must be periodically reevaluated to ensure their effectiveness.

6. How to Use the ORM Process Model. To get maximum benefit from this powerful tool, there are several factors to keep in mind.

6.1. **Apply the Steps in Sequence.** Each of the steps is a building block for the next step. It is important to complete each step, however briefly, before proceeding to the next step. For example, if the hazard identification step is interrupted to focus on control of a particular hazard before the identification step is complete, other more important hazards may be overlooked and the ORM process may be distorted. Until the hazard identification step is complete, it is not possible to properly prioritize risk control efforts.

6.2. **Maintain Balance in the Process.** All six steps are important. If an hour is available to apply the ORM process, it is important not to lose sight of the total process. Spending 50 minutes of the hour on hazard identification may not leave enough time to effectively apply the other five steps of the process. The result is suboptimal risk management. Of course, it would be simplistic to rigidly insist that each of the six steps gets 10 minutes. The idea is to assess the time and resources available for ORM activities and allocate them to the six steps in a manner most likely to produce the best overall result.

6.3. **Apply the Process as a Cycle.** Notice that the “Supervise and Review” step feeds back into the first step. It is this cyclic characteristic that generates the continuous improvement characteristics of the ORM process. When the “Supervise and Review” step establishes that some risks have been significantly reduced, the hazard identification step is reapplied to find new hazard targets. In this way, the ORM process is continually reevaluating the risks.

6.4. **Involve People Fully.** The only way to assure the ORM process is supportive is to provide for the full involvement of the people actually exposed to the risks. Take the time to periodically revalidate ORM procedures and assure that they are mission supportive and are viewed by personnel as positive.

7. ORM Integration. A key objective of ORM is to accomplish the ORM process as an integrated aspect of mainstream mission processes. When ORM is effectively integrated, it quickly ceases to be consciously identifiable as a separate process. To effectively apply risk management, commanders must dedicate time and resources to incorporate risk management principles into the planning processes. Risks are more easily assessed and managed in the planning stages of an operation. Integrating risk management into planning as early as possible provides the decision maker the greatest opportunity to apply ORM principles.

8. Types of Risk. Figure 3 depicts the relationship between the various types of risk.

8.1. *Total Risk* is the sum of *Identified Risk* and *Unidentified Risk*.

8.2. *Identified Risk* is risk that has been determined through various analysis tools. The first task in the risk assessment process is to make identified risk as large a piece of the overall pie as practical. The time and costs of analysis efforts, the quality of the risk management program, and the state of technology impact the amount of risk identified.

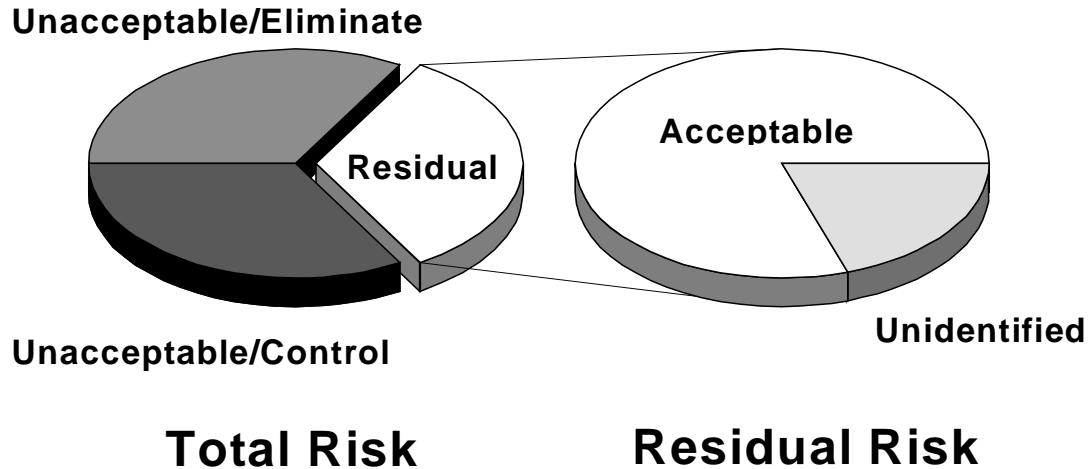
8.3. *Acceptable Risk* is the part of *Identified Risk* that is allowed to persist without further controls. It is accepted by the appropriate decision maker because further efforts at risk control would cause greater offsetting degradation in other aspects of the mission.

8.4. *Unacceptable Risk* is the risk that cannot be tolerated. It is a subset of *Identified Risk* that is either eliminated or controlled.

8.5. *Unidentified Risk* is the risk that hasn't yet been determined. It's real. It's important. But it's not known or measurable. Some risks are never known.

8.6. *Residual Risk* is the risk that remains after risk management efforts have been employed. It is often erroneously thought of as being *Acceptable Risk*. Actually, *Residual Risk* is the sum of *Acceptable Risk* and *Unidentified Risk*. Mishap investigations may uncover some previously unknown risks.

Figure 3. Types of Risk.



9. Benefits. Risk management is a logical process of weighing potential costs of risks versus anticipated benefits. Benefits are not limited to reduced mishap rates or decreased injuries, but may be actual increases in efficiency or mission effectiveness. Examples of potential benefits include:

9.1. Audacity through prudent risk taking. Bold and even risky actions may be undertaken when the benefits have been carefully weighed against the probability and severity of loss.

9.2. Improved ability to protect the force with minimal losses. Analysis of current practices may reduce risks we currently accept.

9.3. Enhanced decision-making skills. Decisions are based on a reasoned and repeatable process instead of relying on intuition.

9.4. Improved confidence in unit capabilities. Adequate risk analysis provides a clearer picture of unit strengths and weaknesses.

10. Acceptability of Risk.

10.1. Applying risk management requires a clear understanding of what constitutes “unnecessary risk,” when benefits actually outweigh costs. Accepting risk is a function of both risk assessment and risk management. Risk acceptance is not as elementary a matter as it may first appear. Several points must be kept in mind.

- 10.1.1. Some degree of risk is a fundamental reality.
- 10.1.2. Risk management is a process of tradeoffs.
- 10.1.3. Quantifying risk alone does not ensure safety.
- 10.1.4. Risk is a matter of perspective.

10.2. Realistically, some risk must be accepted. How much is accepted, or not accepted, is the prerogative of the defined decision authority. That decision is affected by many inputs. As tradeoffs are considered and mission planning progresses, it may become evident that some of the safety parameters are forcing higher risk to successful mission completion. From the commander’s perspective, a relaxation of one or more of the established safety parameters may appear to be advantageous when considering the broader perspective of overall mission success. When a commander or manager decides to accept risk, the decision should be coordinated whenever practical with the affected personnel and organizations, and then documented so that in the future everyone will know and understand the elements of the decision and why it was made.

10.3. General risk management guidelines are:

- 10.3.1. All human activity involving a technical device or complex process entails some element of risk.
- 10.3.2. Do not panic at every hazard; there are ways of controlling them.
- 10.3.3. Keep problems in proper perspective.
- 10.3.4. Weigh risks and make judgments based on knowledge, experience, and mission requirements.
- 10.3.5. Encourage others to adopt similar risk management principles.
- 10.3.6. Operations always represent a gamble to some degree; good analysis tilts the odds in your favor.
- 10.3.7. Hazard analysis and risk assessment do not free us from reliance on good judgment, they improve it.
- 10.3.8. It is more important to establish clear objectives and parameters for risk assessment than to find a “cookbook” approach and procedure.
- 10.3.9. There is no “best solution.” There are normally a variety of directions to go. Each of these directions may produce some degree of risk reduction.
- 10.3.10. To point out to a mission planner how he can manage risk better is much more effective than to tell him his approach will not work.
- 10.3.11. Complete safety is a condition that seldom can be achieved in a practical manner.

10.3.12. There are no “safety problems” in mission planning or design. There are only management problems that, if left unresolved, may cause mishaps.

11. Risk Management Responsibilities:

11.1. Commanders:

- 11.1.1. Are responsible for effective management of risk.
- 11.1.2. Select from risk reduction options provided by the staff.
- 11.1.3. Accept or reject risk based on the benefit to be derived.
- 11.1.4. Train and motivate leaders to use risk management.
- 11.1.5. If not authorized to accept high level risks, elevate to the appropriate level.

11.2. Staff:

- 11.2.1. Assess risks and develop risk reduction options.
- 11.2.2. Integrate risk controls into plans and orders.
- 11.2.3. Identify unnecessary risk controls.

11.3. Supervisors:

- 11.3.1. Apply the risk management process and direct personnel to use it both on- and off-duty.
- 11.3.2. Consistently apply effective risk management concepts and methods to operations and tasks.
- 11.3.3. Elevate risk issues beyond their control or authority to superiors for resolution.

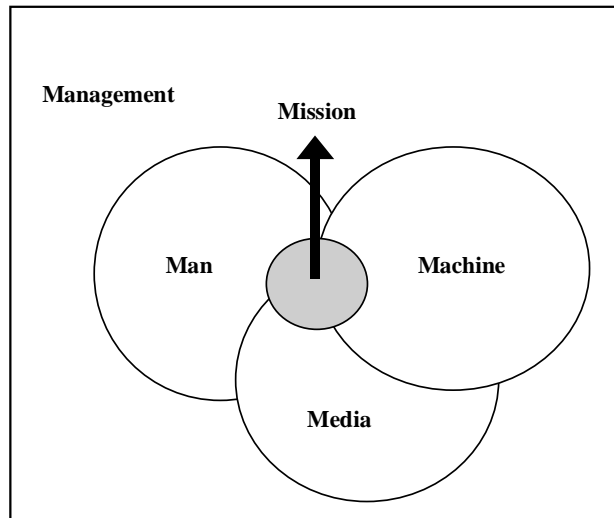
11.4. Individuals:

- 11.4.1. Understand, accept, and implement risk management processes.
- 11.4.2. Maintain a constant awareness of the changing risks associated with the operation or task.
- 11.4.3. Make supervisors immediately aware of any unrealistic risk reduction measures or high risk procedures.

12. Systematic Risk Management. Risk management is the systematic application of management and engineering principles, criteria and tools to optimize all aspects of safety within the constraints of operational effectiveness, time, and cost throughout all mission phases. To apply the systematic risk management process, the composite of hardware, procedures, and people that accomplish the mission or produce mishaps, must be viewed as a system.

12.1. The 5-M Model. The 5-M model, Figure 4, provides a basic framework for analyzing systems and determining the relationships between composite elements that work together to perform the mission. The 5-M's are Man, Machine, Media, Management, and Mission. Man, Machine, and Media interact to produce a successful Mission or, sometimes, an unsuccessful one. The amount of overlap or interaction between the individual components is a characteristic of each system and evolves as the system develops. Management provides the procedures and rules governing the interactions between the various elements.

Figure 4. 5-M Model.



12.2. Figure 4 is a generalized model of a mission system. There is significant overlap between Man, Machine, and Media, because these elements interrelate directly, but the critical element is Management because it defines how the other elements interact. When a Mission is unsuccessful or a Mishap occurs, the system must be analyzed: the inputs and interaction between the 5-Ms must be thoroughly reassessed. Management is often the controlling factor in mission success or failure. Military safety centers and the National Safety Council cite the management processes in as many as 80 percent of reported mishaps.

12.3. Successful missions, or mishaps, do not just happen, they are indicators of how well a system is functioning. The basic cause factors for mishaps fall into the same categories as the contributors to successful missions—Man, Media, Machine, and Management.

12.3.1. Man. Area of greatest variability and thus the majority of risks.

12.3.1.1. *Selection*: Right person psychologically/physically, trained in event proficiency, procedural guidance, habit pattern.

12.3.1.2. *Performance*: Awareness, perceptions, task saturation, distraction, channelized attention, stress, peer pressure, confidence, insight, adaptive skills, pressure/workload, fatigue (physical, motivational, sleep deprivation, circadian rhythm).

12.3.1.3. *Personal Factors*: Expectancies, job satisfaction, values, families/friends, command/control, discipline (internal and external), perceived pressure (over tasking) and communication skills.

12.3.2. Media. External, largely environmental forces.

12.3.2.1. *Climatic*: Ceiling, visibility, temperature, humidity, wind, precipitation.

12.3.2.2. *Operational*: Terrain, wildlife, vegetation, man made obstructions, daylight, darkness.

12.3.2.3. *Hygienic*: Ventilation/air quality, noise/vibration, dust, contaminants.

12.3.2.4. *Vehicular/Pedestrian*: Pavement, gravel, dirt, ice, mud, dust, snow, sand, hills, curves.

12.3.3. Machine. Used as intended, limitations, interface with man.

12.3.3.1. *Design*: Engineering reliability and performance, ergonomics.

12.3.3.2. *Maintenance*: Availability of time, tools, and parts, ease of access.

12.3.3.3. *Logistics*: Supply, upkeep, repair.

12.3.3.4. *Tech data*: Clear, accurate, useable, available.

12.3.4. *Management*. Directs the process by defining Standards, Procedures, and Controls. Be aware that while management provides procedures and rules to govern interactions, it cannot completely control the system elements. For example: weather is not under management control and individual decisions affect off-duty personnel much more than management policies.

12.3.4.1. *Standards*: Doctrine statements, various criteria, policy, and AF Policy Directives.

12.3.4.2. *Procedures*: Checklists, work cards, T.O.'s, multi-command manuals, and AFIs.

12.3.4.3. *Controls*: Crew rest, altitude/airspeed/speed limits, restrictions, training rules/limitations, rules of engagement (ROE), lawful orders.

12.3.5. *Mission*. The desired outcome.

12.3.5.1. *Objectives*: Complexity understood, well defined, obtainable.

12.3.5.2. The results of the interactions of the 4-M's (Man, Media, Machine, and Management).

13. Levels of Risk Management. The risk management process exists on three levels. While it would be preferable to perform an in-depth application of risk management for every mission or task, time and resources may not always be available. One of the objectives of risk management training is to develop sufficient proficiency in applying the process so that risk management becomes an automatic part of the decision making methodology on- and off-duty. Leaders must be able to employ the risk management process to make sound and timely decisions. The three levels are as follows:

13.1. *Time-Critical*: Time-critical risk management is an "on the run" mental or verbal review of the situation using the basic risk management process without necessarily recording the information. This time-critical process of risk management is employed by personnel to consider risk while making decisions in a time-compressed situation. This level of risk management is used during the execution phase of training or operations as well as in planning and execution during crisis responses. It is also the most easily applied level of risk management in off-duty situations. It is particularly helpful for choosing the appropriate course of action when an unplanned event occurs during execution of a planned operation or daily routine.

13.2. *Deliberate*: Deliberate Risk Management is the application of the complete process. It primarily uses experience and brainstorming to identify hazards and develop controls and is therefore most effective when done in a group. Examples of deliberate applications include the planning of upcoming operations, review of standard operating, maintenance, or training procedures, and damage control or disaster response planning.

13.3. *Strategic*: This is the deliberate process with more thorough hazard identification and risk assessment involving research of available data, use of diagram and analysis tools, formal testing, or long term tracking of the hazards associated with the system or operation (normally with assistance from technical experts). It is used to study the hazards and their associated risks in a complex operation or system, or one in which the hazards are not well understood. Examples of strategic applications include the long-term planning of complex operations, introduction of new equipment, materials and missions,

development of tactics and training curricula, high risk facility construction, and major system overhaul or repair. Strategic risk management should be used on high priority or high visibility risks.

14. Applying Opportunity-Risk and Training Realism Procedures. Just as every organization should be targeting its more important risk issues, it should also be systematically targeting risk barriers to expanded operational capabilities and increased training realism. All important organizational missions should be analyzed to determine the risk barriers to expanded capabilities. Procedures should be in place to use the tools of risk management to break through these barriers. As a general rule, about half the effort expended on ORM should be directed toward using risk management to expand operational capabilities and effectiveness. The other half is directed at reducing various types of risk.

15. Section C—Step 1—Identify Hazards

15. Introduction. Hazard identification is the foundation of the entire ORM process. Obviously if a hazard is not identified it can not be controlled. The effort expended in identifying hazards will have a multiplier effect on the impact of the total ORM process. Figure 5 depicts the actions necessary to complete this step.

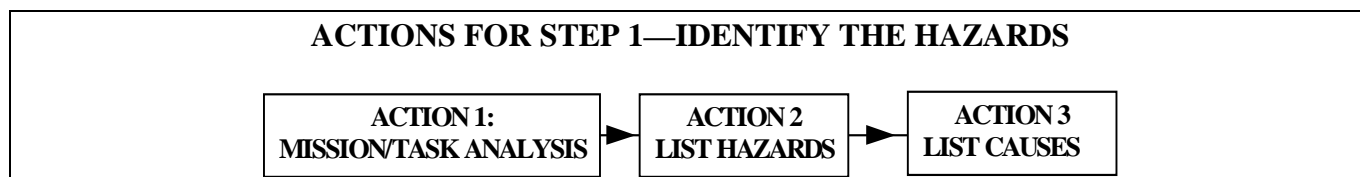
15.1. Identify hazards associated with these three categories:

15.1.1. Mission Degradation.

15.1.2. Personal Injury or Death.

15.1.3. Property Damage.

Figure 5. Step 1—Identify Hazards Actions.



16. Action 1—Mission/Task Analysis. The 5-M's are examined. This is accomplished by reviewing current and planned operations describing the mission. The commander defines requirements and conditions to accomplish the tasks. Construct a list or chart depicting the major phases of the operation or steps in the job process, normally in time sequence. Break the operation down into 'bite size' chunks. Some tools that will help perform mission/task analysis are:

16.1. Operations Analysis/Flow Diagram (simple, easy)

16.2. Preliminary Hazard Analysis (PHA) (simple, easy)

16.3. Multilinear Events Sequence (MES) (detailed, complex)

17. Action 2—List Hazards. Hazards, and factors that could generate hazards, are identified based on the deficiency to be corrected and the definition of the mission and system requirements. The output of the identification phase is a listing of inherent hazards or adverse conditions and the mishaps which could result. Examples of inherent hazards in any one of the elements include fire, explosion, collision with ground, wind, or electrocution. The analysis must also search for factors that can lead to hazards such as alertness, ambiguity, or escape route. In addition to a hazard list for the elements above, interfaces between or among these elements should be investigated for hazards. An airman required to make critical and delicate adjustment to an aircraft on a cold, dark night, handling of an air-to-air missile with missile-handling equipment, or frost-bite would be examples of the "interface hazards." Make a list of the hazards associated with each phase of the operation or step in the job process. Stay focused on the specific steps in the operation being analyzed. Try to limit your list to "big picture" hazards. Hazards should be tracked on paper or in a computer spreadsheet/database system to organize ideas and serve as a record of the analysis for future use. Tools that help list hazards are:

17.1. Preliminary Hazard Analysis

17.2. "What if" Tool

17.3. Scenario Process Tool

17.4. Logic Diagram

- 17.5. Change Analysis Tool
- 17.6. Opportunity Assessment
- 17.7. Training Realism Assessment.

18. Action 3—List Causes. Make a list of the causes associated with each hazard identified in the hazard list. A hazard may have multiple causes related to each of the 5-M's. In each case, try to identify the root cause (the first link in the chain of events leading to mission degradation, personnel injury, death, or property damage). Risk controls can be effectively applied to root causes. Causes should be annotated with the associated hazards in the same paper or computer record mentioned in the previous action. The same tools for Action 2 can be used here.

19. Strategic Tools. If time and resources permit, and additional hazard information is required, use strategic hazard analysis tools. These are normally used for medium and long term planning, complex operations, or operations in which the hazards are not well understood.

19.1. The first step of in-depth analysis should be to examine existing databases or available historical and hazard information regarding the operation. Suggested tools are:

- 19.1.1. The mission mishap analysis.
- 19.1.2. Cause and effect diagrams.

19.2. The following tools are particularly useful for complex, coordinated operations in which multiple units, participants, and system components and simultaneous events are involved:

- 19.2.1. Multilinear event sequence (MES).
- 19.2.2. Interface analysis.
- 19.2.3. Failure mode and effect analysis.

19.3. The following tools are particularly useful for analyzing the hazards associated with physical position and movement of assets:

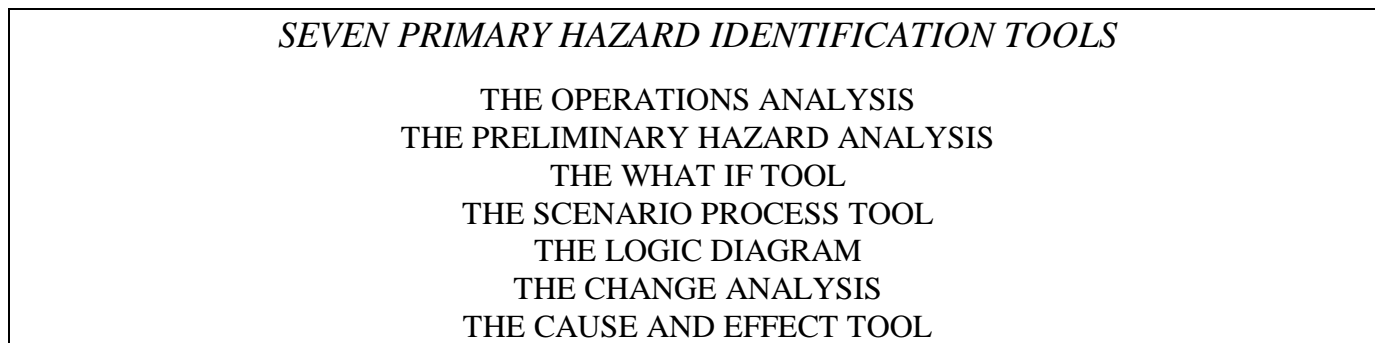
- 19.3.1. Mapping tool.
- 19.3.2. Energy trace and barrier analysis.
- 19.3.3. Interface analysis.

20. Tool selection and other resources. It is impractical for the USAF to create detailed procedures to ensure the “right” tools are utilized for every activity and every contingency. On the other hand, choosing the best tools is important when we are planning to undertake a potentially hazardous operation. Most of the tools mentioned can be used in a variety of creative ways. Additionally, there are a number of tools that were not mentioned in the preceding paragraphs but are included in Attachment 2 since there are specific situations where they may be the best choice. It is up to the user to select the appropriate tool or combination of tools and the extent of effort to expend on each. Since there are generally no right or wrong selections, knowledge and experience will help in making the choice. Details and examples of their use is provided at Attachment 2.

20.1. Although there are numerous tools listed within Attachment 2, the most frequently used tools are depicted at Figure 6 and are included in Section A2.A of Attachment 2. These tools are normally used in

the sequence indicated, however it is important for the user to become familiar with them and choose the best combination for a particular situation.

Figure 6. The Primary Family of Hazard Identification Tools.



20.2. There are many additional tools that can help identify hazards. One of the best is through a group process involving representatives directly from the workplace. Most people want to talk about their jobs, therefore a simple brainstorming process with a facilitator is often very productive. The following is a partial list of other sources of hazard identification information:

20.2.1. Mishap Reports: These can come from within the organization, from tenants, within the chain of command, from outside the chain (other bases, wings, MAJCOMs, etc.), other services, DoD agencies, etc. Obviously, a missionized identification is the best, for it represents corporate memory applicable to the local workplace, cockpit, mission, etc. Other sources might be medical reports, maintenance records, and fire and police reports.

20.2.2. Unit Personnel: Relevant experience is arguably the best source of hazard identification. Reinventing the wheel each time an operation is proposed is neither desired nor efficient. Seek out those with whom you work who have participated in similar operations and solicit their input.

20.2.3. Outside Experts: Look to those outside your organization for expert opinions or advice. Possible sources of help include Safety, Quality Assurance, manufacturers, depots, and other bases.

20.2.4. Current Guidance: A wealth of relevant direction can always be found in the guidance that governs our operations. Consider regulations, operating instructions, checklists, briefing guides, syllabi, FCIFs, SOPs, NOTAMs, and policy letters.

20.2.5. Evaluation and inspection reports: Functional and IG visits provide important feedback and written documentation on local process management.

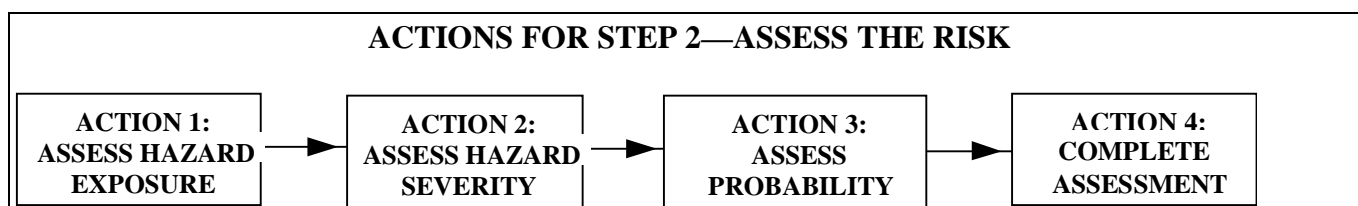
20.2.6. Surveys: These can be unit generated. Target an audience and ask some very simple questions related to such topics as: What will your next mishap be? Who will have it? What task will cause it? When will it happen? The survey can be a powerful tool because it pinpoints people in the workplace with first hand knowledge of the job. Often, first line supervisors in the same workplace do not have as good an understanding of risk as those who confront it every day.

20.2.7. Inspections: Inspections can consist of spot checks, walk throughs, checklist inspections, site surveys, and mandatory inspections. Utilize people in the workplace to provide input beyond the standard third-party inspection.

Section D—Step 2—Assess Risk

21. Introduction. Risk assessment is the process which associates “hazards” with “risks”. When we know the various impacts a hazard may have on our mission and an estimate of how likely it is to occur we can now call the hazard a risk. The second aspect of risk assessment is the ranking of risks into a priority order. Figure 7 depicts the actions necessary to complete this step. The number one risk is the one with the greatest potential impact on the command mission. The last risk is the least risky issue that still may deserve some attention and possible risk control action. Keep in mind that this priority listing is intended to be used as a guide to the relative priority of the risks involved and not necessarily an absolute order to be followed. There may be, as an example, something that is not a terribly significant risk that is extremely simple to control.

Figure 7. Step 2—Assess the Risk Actions.



22. The Components of Risk. There are three key aspects of risk. Probability is the estimate of the likelihood that a hazard will cause a loss. Some hazards produce losses frequently, others almost never do. Severity is the estimate of the extent of loss that is likely. The third key aspect is exposure, which is the number of personnel or resources affected by a given event or, over time, by repeated events. To place hazards in rank order we must make the best possible estimate of the probability, severity, and exposure of a risk compared to the other risks that have been detected. A complete description of this concept, including an application of the risk assessment matrix and an example of a risk totem pole, are at Attachment 3.

23. Action 1—Assess Hazard Exposure. Surveys, inspections, observations, and mapping tool can help determine the level of exposure to the hazard and record it. This can be expressed in terms of time, proximity, volume, or repetition. Does it happen often, or near personnel or equipment? Does the event involve a lot of people or equipment? Repeated exposure to a hazard increases the probability of a mishap occurring. Understanding the exposure level can aid in determining the severity or the probability of the event. Additionally, it may serve as a guide for devising control measures to limit exposure.

24. Action 2—Assess Hazard Severity. Determine the severity of the hazard in terms of its potential impact on the people, equipment, or mission. Cause and effect diagrams, scenarios and “What-If” analysis are some of the best tools for assessing the hazard severity. Severity assessment should be based upon the worst possible outcome that can reasonably be expected. Severity categories are defined to provide a qualitative measure of the worst credible mishap resulting from personnel error, environmental conditions; design inadequacies; procedural deficiencies; or system, subsystem, or component failure or malfunction. The following severity categories provide guidance to a wide variety of missions and systems.

24.1. Severity Categories

- 24.1.1. CATASTROPHIC—Complete mission failure, death, or loss of system
- 24.1.2. CRITICAL—Major mission degradation, severe injury, occupational illness or major system damage
- 24.1.3. MODERATE—Minor mission degradation, injury, minor occupational illness, or minor system damage
- 24.1.4. NEGLIGIBLE—Less than minor mission degradation, injury, occupational illness, or minor system damage

25. Action 3—Assess Probability. Determine the probability that the hazard will cause a negative event of the severity assessed in Action 2 above. Probability is proportional to the cumulative probability of the identified causes for the hazard. Probability may be determined through estimates or actual numbers, if they are available. Assigning a quantitative mishap probability to a new mission or system may not be possible early in the planning process. A qualitative probability may be derived from research, analysis, and evaluation of historical safety data from similar missions and systems. The typical mishap sequence is much more complicated than a single line of erect dominos where tipping the first domino (hazard) triggers a clearly predictable reaction. Supporting rationale for assigning a probability should be documented for future reference. The following are generally accepted definitions for probability:

25.1. Probability

25.1.1. FREQUENT

- 25.1.1.1. Individual item—Occurs often in the life of the system
- 25.1.1.2. Fleet or inventory—Continuously experienced
- 25.1.1.3. Individual Airman—Occurs often in career
- 25.1.1.4. All Airmen exposed—continuously experienced

25.1.2. LIKELY

- 25.1.2.1. Individual item—Occurs several times in the life of the system
- 25.1.2.2. Fleet or Inventory—Occurs regularly
- 25.1.2.3. Individual Airman—Occurs several times in a career
- 25.1.2.4. All Airmen exposed—Occurs regularly

25.1.3. OCCASIONAL

- 25.1.3.1. Individual item—Will occur in the life of the system
- 25.1.3.2. Fleet or Inventory—Occurs several times in the life of the system
- 25.1.3.3. Individual Airman—Will occur in a career
- 25.1.3.4. All Airmen exposed—Occurs sporadically

25.1.4. SELDOM

- 25.1.4.1. Individual item—May occur in the life of the system
- 25.1.4.2. Fleet or Inventory—Can be expected to occur in the life of the system
- 25.1.4.3. Individual Airman—May occur in a career
- 25.1.4.4. All Airmen exposed—Occurs seldom

25.1.5. UNLIKELY

- 25.1.5.1. Individual item—So unlikely you can assume it will not occur in the life of the system
- 25.1.5.2. Fleet or Inventory—Unlikely but could occur in the life of the system
- 25.1.5.3. Individual Airman—So unlikely you can assume it will not occur in a career
- 25.1.5.4. All Airmen exposed—Occurs very rarely

26. Action 4—Complete Risk Assessment. Combine severity and probability estimates to form a risk assessment for each hazard. By combining the probability of occurrence with severity, a matrix is created where intersecting rows and columns define a Risk Assessment Matrix. The Risk Assessment Matrix forms the basis for judging both the acceptability of a risk and the management level at which the decision on acceptability will be made. The matrix may also be used to prioritize resources to resolve risks due to hazards or to standardize hazard notification or response actions. Severity, probability, and risk assessment should be recorded to serve as a record of the analysis for future use. Existing databases, Risk Assessment Matrix, or a panel of personnel experienced with the mission and hazards can be used to help complete the risk assessment. Figure 8 is an example of a matrix.

Figure 8. Sample Risk Assessment Matrix.

			Probability				
			Frequent	Likely	Occasional	Seldom	Unlikely
			A	B	C	D	E
S E V E R I T Y	Catastrophic	I	Extremely				
	Critical	II	High	High			
	Moderate	III		Medium			
	Negligible	IV					Low
			Risk Levels				

27. Assessment Pitfalls. The following are some analytical pitfalls that should be avoided in the assessment:

27.1. *Overoptimism:* “It can’t happen to us. We’re already doing it.” This pitfall results from not being totally honest and not looking for root causes of risk.

27.2. *Misrepresentation:* Individual perspectives may distort data. This can be deliberate or unconscious.

27.3. *Alarmism:* “The sky’s falling” approach, or “worst case” estimates are used regardless of their remote possibility.

27.4. *Indiscrimination:* All data is given equal weight.

27.5. *Prejudice:* Subjectivity and/or hidden agendas are used, rather than facts.

27.6. *Inaccuracy:* Bad or misunderstood data nullifies accurate risk assessment.

27.6.1. It is difficult to assign a numerical value to human behavior.

27.6.2. Numbers may oversimplify real life situations.

27.6.3. It may be difficult to get enough applicable data, which could force inaccurate estimates.

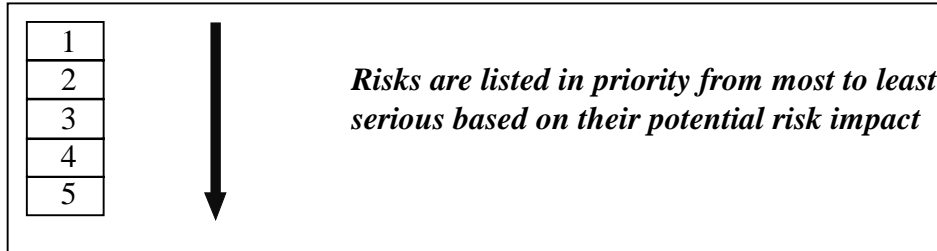
27.6.4. Oftentimes numbers take the place of reasoned judgment.

27.6.5. Risk can be unrealistically traded off against benefit by relying solely on numbers

28. The Output of the Risk Assessment Step. The outcome of the risk assessment process is a list of risks developed from the output of the hazard identification process. The first risk is the most serious threat to the mission, the last is the least serious risk of any consequence (see Figure 9). Each risk is either

labeled with its significance (high, medium, etc.) or the section in which it is place is labeled. This allows us to see both the relative priority of the risks and their individual significance.

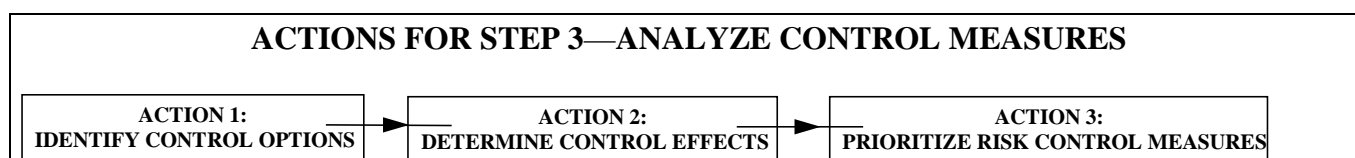
Figure 9. The Risk Ranking Concept.



Section E— Step 3—Analyze Control Measures

29. Introduction. Step 3 involves the targeting of priority risk issues for control. Control is accomplished in several ways. Attachment 4 defines each of these options in detail. Figure 10 depicts the actions necessary to complete this step.

Figure 10. Step 3—Analyze Control Measures Actions.



30. Action 1—Identify Control Options. Starting with the highest-risk hazards as assessed in Step 2, identify as many risk control options as possible for all hazards. Refer to the list of possible causes from Step 1 for control ideas. The Control Options Matrix, Mission mishap analysis, and “What-If” analyses are excellent tools to identify control options. Risk control options include: *rejection, avoidance, delay, transference, spreading, compensation, and reduction.*

31. Action 2—Determine Control Effects. Determine the effect of each control on the risk associated with the hazard. A computer spread sheet or data form may be used to list control ideas and indicate control effects. The estimated value(s) for severity and/or probability after implementation of control measures and the change in overall risk assessed from the Risk Assessment Matrix should be recorded. Scenario building and next mishap assessment provide the greatest ability to determine control effects.

32. Action 3—Prioritize Risk Controls. For each hazard, prioritize those risk controls that will reduce the risk to an acceptable level. The best controls will be consistent with mission objectives and optimize use of available resources (manpower, material, equipment, money, time). Priorities should be recorded in some standardized format for future reference. Opportunity assessment, cost versus benefit analysis and computer modeling provide excellent aids to prioritize risk controls. If the control is already implemented in an established instruction, document, or procedure, that too should be documented.

32.1. The "standard order of precedence" indicates that the ideal action is to “plan or design for minimum risk” with less desirable options being, in order, to add safety devices, add warning devices, or change procedures and training. This order of preference makes perfect sense while the system is still being designed, but once the system is fielded this approach is frequently not cost effective. Redesigning to eliminate a hazard or add safety or warning devices is both expensive and time consuming and, until the retrofit is complete, the hazard remains unabated.

32.2. Normally, revising operational or support procedures may be the lowest cost alternative. While this does not eliminate the hazard, it may significantly reduce the likelihood of a mishap or the severity of the outcome (risk) and the change can usually be implemented quickly. Even when a redesign is planned, interim changes in procedures or maintenance requirements are usually required. In general, these changes may be as simple as improving training, posting warnings, or improving operator or technician qualifications. Other options include preferred parts substitutes, instituting or changing time change requirements, or increased inspections.

32.3. The feasible alternatives must be evaluated, balancing their costs and expected benefits in terms of mission performance, dollars and continued risk exposure during implementation. A completed risk assessment should clearly define these tradeoffs for the decision maker.

33. Some Special Considerations in Risk Control. The following factors should be considered when applying the third step of ORM.

33.1. Try to apply risk controls only in those activities and to those personnel who are actually at risk. Too often risk controls are applied indiscriminately across an organization leading to wasted resources and unnecessary irritation of busy operational personnel.

33.2. Apply redundant risk controls when practical and cost effective. If the first line of defense fails, the back up risk control(s) may prevent loss.

33.3. Involve operational personnel, especially those likely to be directly impacted by a risk control, in the selection and development of risk controls whenever possible. This involvement will result in better risk controls and in general a more positive risk control process.

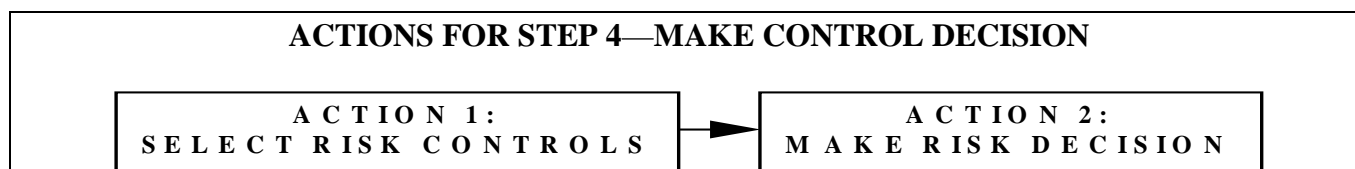
33.4. Benchmark (find best practices in other organizations) as extensively as possible to reduce the cost associated with the development of risk controls. Why expend the time and resources necessary to develop a risk control and then have to test it in application when you may be able to find an already complete, validated approach in another organization?

33.5. Establish a timeline to guide the integration of the risk control into operational processes.

Section F—Step 4—Make Control Decisions

34. Introduction. Step 4, Make Control Decisions, involves two major dimensions. The first is the selection of the risk controls to actually use from among those developed in the Develop Risk Controls step (step 3). The second is the decision whether or not to accept the residual risk present in a mission or project after applying all practical risk controls. The decision maker selects the control options after being briefed on all the possible controls. It is not an ad hoc decision, but rather is a logical, sequenced part of the risk management process. Decisions are made with awareness of hazards and how important hazard control is to mission success or failure (cost versus benefit). Control decisions must be made at the appropriate level. The decision maker must be in a position to obtain the resources needed to implement the risk controls he or she approves. Usually, the earlier in the life of the process that control is implemented, the cheaper it is. Modifying aircraft ten years after production costs the Air Force millions, whereas modifications during production would have been more cost effective. When making control decisions, it is important to keep in mind the law of diminishing returns. There is a point at which it is no longer cost effective to continue applying control measures for the small amount of additional return in terms of reduced risk. Figure 11 depicts the actions necessary to complete this step.

Figure 11. Step 4—Make Control Decisions Actions.



35. Action 1—Select Risk Controls. For each identified hazard, select those risk controls that will reduce the risk to an acceptable level. The best controls will be consistent with mission objectives and optimum use of available resources (manpower, material, equipment, money, and time). Implementation decisions should be recorded in some standardized format for future reference.

36. Action 2—Make Risk Decision. Analyze the level of risk for the operation with the proposed controls in place. Determine if the benefits of the operation now exceed the level of risk the operation presents. Be sure to consider the cumulative risk of all the identified hazards and the long term consequences of the decision. When a decision is made to assume risk, the factors (cost versus benefit information) involved in this decision should be recorded. Documentation is important to provide future leaders and managers the steps necessary to mitigate or accept the hazard associated with the risk. This will be critical to the success of Step 6 (Supervise and Review) in the overall risk management process.

36.1. If the costs of the risk outweighs the benefits, re-examine the control options to see if any new or modified controls are available. If no additional controls are identified, inform the next level in the chain of command that, based on the evaluation, the risk of the mission exceeds the benefits and should be modified.

36.2. If the benefits of the mission outweigh the risk, with controls in place, determine if the controls can all be implemented at your level in the chain of command. If they cannot, notify the chain of command of the need for assistance.

36.3. When notified of a situation in which risk outweighs benefit, the next level in the chain of command should either assist with implementing required controls, modify or cancel the mission, or accept the identified risks based on a higher level of the risk-benefit equation. When practical, a higher level decision-maker should explain to lower level personnel the basis on which the risk decision is reached. This allows the lower level personnel to understand the reasons for proceeding and helps expand their decision-making experience base.

37. Decisions Regarding Risk Controls. The objective of this aspect of decision making is to select the best possible combination of risk controls from among the options provided by the application of the risk control options matrix in Step 3. There are several important points to keep in mind when making a risk control decision.

37.1. Involve the personnel impacted by the risk controls to the maximum possible extent in the selection. They can almost always provide ideas to enhance the various options.

37.2. Carefully evaluate the mission impact of the various risk control options. The most effective risk control may also be the one that has the most negative impact on other aspects of the mission. The objective is to choose the option(s) that has the best overall favorable impact on the mission.

37.3. Be sure to consider all the positive (benefit) and negative (cost) factors associated with a risk decision. A common mistake is to consider only the safety or other loss control aspects of risk decisions. Often more important issues are the quality, productivity, or morale implications of the decision.

37.4. Try to focus risk controls only on those parts of the operation actually impacted by the risk. This may be a specific group of personnel, a particular phase of the operation, or a particular piece of equipment. By tightening the focus, resource requirements are minimized and any negative mission impact is reduced.

37.5. Make risk decisions at the right time. It is important to review a project or mission and identify the points in time at which risk decisions can best be made. On one hand, making risk decisions at the latest possible time provides more time for collecting and considering hazards and associated risks. On the other hand, decisions must be made in time to be effectively integrated in the overall mission process.

37.6. Make risk decisions at the right level. The right level is the level that can best judge the full range of issues involved. It is also relevant to ask who will be held accountable if the risk produces a loss. That person should either have a voice in the risk decision or actually make it.

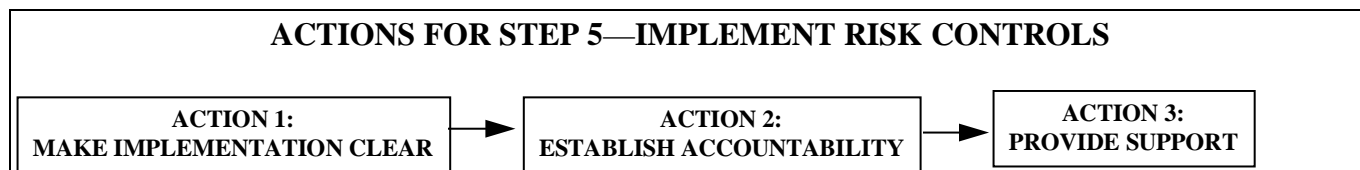
38. Making the Overall Risk Decision. Once the best possible set of risk control options has been selected, the individual in charge must make a final decision whether to proceed, thereby accepting the residual risk of the operation. This decision is based on the best possible estimate whether the overall potential benefit to the organization of a particular mission exceeds the best estimate of the overall potential cost. The third rule of risk management tells us that when the benefits outweigh the costs the risk should be accepted. This is an especially critical concept of ORM. The risk decisions should be based on the question “Which risk is greater, the risk of doing this or the risk of not doing it?” This view of risk

decisions recognizes that organizations are placed at risk when they do not take the risks they need to take to remain superior to or at least competitive with their potential adversaries. It is important to note that the ORM process may occasionally reveal areas where regulatory guidance is overly restrictive or otherwise in need of evaluation, however, ORM is not authorization to violate policy. ORM assessments, properly performed, will serve as a tool to seek necessary changes through established channels. Remember, the goal is not the least level of risk, it is the best level of risk for the total mission of the organization.

Section G—Step 5—Implement Risk Controls

39. Introduction. Implement Risk Controls. Once the risk control decision is made, assets must be made available to implement the specific controls. Part of implementing control measures is informing the personnel in the system of the risk management process results and subsequent decisions. If there is a disagreement, then the decision makers should provide a rational explanation. Careful documentation of each step in the risk management process facilitates risk communication and the rational processes behind risk management decisions. Figure 12 depicts the actions necessary to complete this step.

Figure 12. Step 5—Implement Risk Controls Actions.



40. Action 1—Make Implementation Clear. To make the implementation directive clear, consider using examples, providing pictures or charts, including job aids, etc. Provide a roadmap for implementation, a vision of the end state, and describe successful implementation. The control measure must be deployed in a method that insures it will be received positively by the intended audience. This can best be achieved by designing in user ownership.

41. Action 2—Establish Accountability. Accountability is an important area of ORM. The accountable person is the one who makes the decision (approves the control measures), and hence, the right person (appropriate level) must make the decision. Also, be clear on who is responsible at the unit level for implementation of the risk control.

42. Action 3—Provide Support. To be successful, command must be behind the control measures put in place. Prior to implementing a control measure, get approval at the appropriate command level. Then, explore appropriate ways to demonstrate command commitment (see paragraph 45.). Provide the personnel and resources necessary to implement the control measures. Design in sustainability from the beginning and be sure to deploy the control measure along with a feedback mechanism that will provide information on whether the control measure is achieving the intended purpose.

43. Common Problems in Implementing Risk Controls. A review of the historical record of risk controls indicates that many never achieve their full potential. The primary reason for shortfalls is failure to effectively involve the personnel who are actually impacted by a risk control. Note that virtually all these factors are driven by the failure to properly involve personnel impacted by risk controls in the development and implementation of the risk controls.

- 43.1. The control is inappropriate for the problem.
- 43.2. Operators dislike it.
- 43.3. Leaders dislike it.
- 43.4. It turns out to be too costly (unsustainable).
- 43.5. It is overmatched by other priorities.
- 43.6. It is misunderstood.

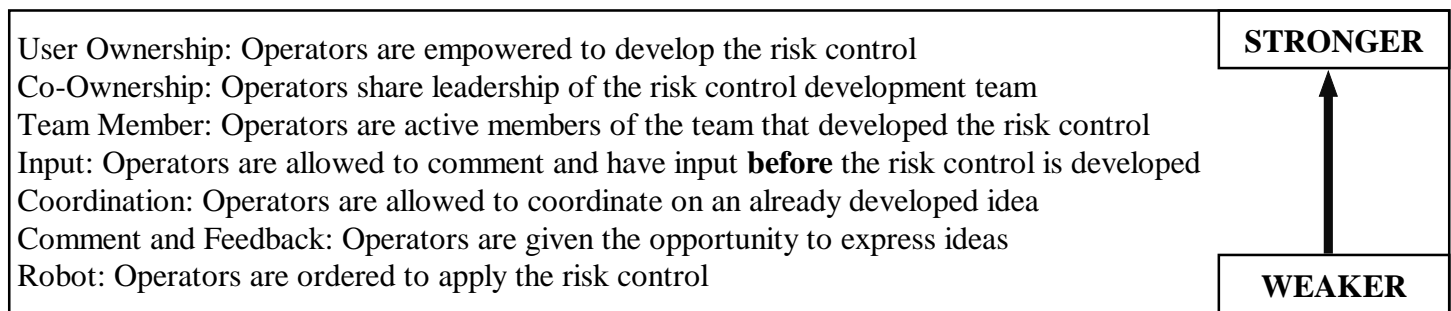
43.7. Nobody measures progress until it is too late.

44. Procedures for Implementing Risk Controls Within an Organizational Culture. The following procedures provide useful guidance for shaping a risk control within an organizational culture. Followed carefully they will significantly improve the impact and duration of the effectiveness of risk controls.

44.1. Develop the risk control within the organization's culture. Every organization has a style or a culture. While the culture changes over time due to the impact of commanders and other modifications, the personnel in the organization know the culture at any given time. It is important to develop risk controls which are consistent with this culture. For example, a rigid, centrally directed risk control would be incompatible with an organizational culture that emphasizes decentralized flexibility. Conversely, a decentralized risk control may not be effective in an organization accustomed to top down direction and control. If you have any doubts about the compatibility of a risk control within your organization, ask some personnel in the organization what they think. People are the culture and their reactions will tell you what you need to know.

44.2. Generate maximum possible involvement of personnel impacted by a risk control in the implementation of the risk control. Figure 13 provides a tool to assist in assessing this "involvement factor." The key to making ORM a fully integrated part of the organization culture, is to achieve user ownership in a significant percentage of all risk controls that are developed and implemented by the personnel directly impacted by the risk.

Figure 13. Levels of User Involvement in Risk Controls.



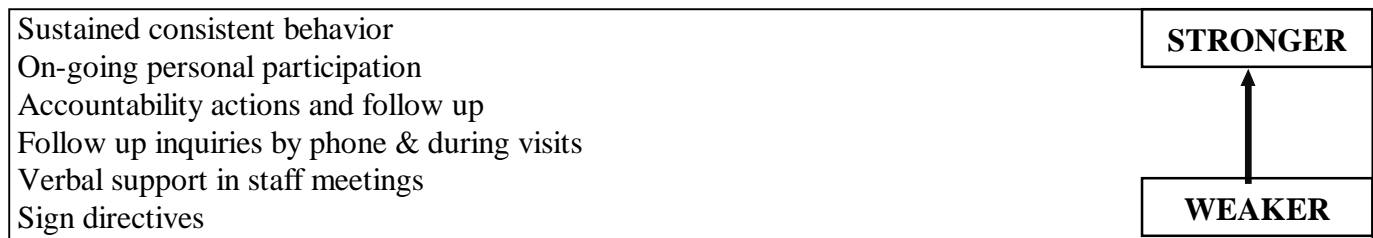
44.3. Develop the best possible supporting tools and guides (infrastructure) to aid operating personnel in implementing the risk control. Examples include standard operating procedures (SOPs), model applications, job aids, checklists, training materials, decision guides, help lines, and similar items. The more support that is provided, the easier the task for the affected personnel. The easier the task, the greater the chances for success.

44.4. Develop a time line for implementing the risk control. Identify major milestones, being careful to allow reasonable timeframes and assuring that plans are compatible with the realities of organizational resource constraints.

45. Procedures for Generating Command Involvement in Implementing Risk Controls. A Commander's and supervisor's influence behind a risk control can greatly increase its chances of success.

It is usually a good idea to signal clearly to an organization that there is leader interest in a risk control if the commander in fact has some interest. Figure 14 illustrates actions in order of priority that can be taken to signal leader support. Most commanders are interested in risk control and are willing to do anything reasonable to support the process. Take the time as you develop a risk control to visualize a role for organization leaders.

Figure 14. Levels of Command Involvement.

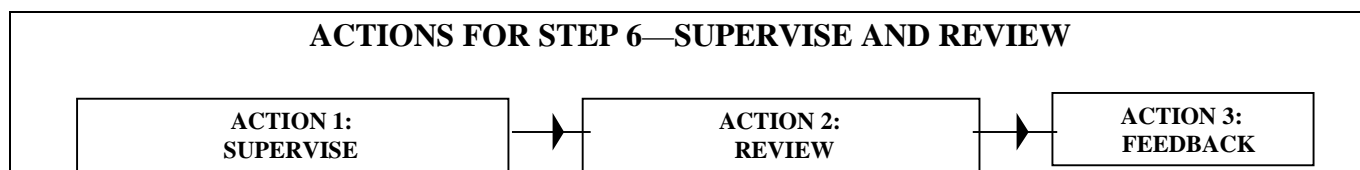


46. Procedures for Sustaining Risk Control Effectiveness. To be fully effective, risk controls must be sustained. This means maintaining the responsibility and accountability for the long haul. If the risk control has been well designed for compatibility with the organization mission and culture this should not be difficult. Leaders must maintain accountability and yet provide a reasonable level of positive reinforcement as appropriate.

Section H—Step 6—Supervise And Review

47. Introduction. The sixth step of ORM, Supervise and Review, involves the determination of the effectiveness of risk controls throughout the operation. This step involves three aspects. The first is monitoring the effectiveness of risk controls. The second is determining the need for further assessment of either all or a portion of the operation due to an unanticipated change as an example. The last is the need to capture lessons-learned, both positive and negative, so that they may be a part of future activities of the same or similar type. Figure 15 depicts the actions necessary to complete this step.

Figure 15. Step 6—Supervise And Review Actions.



48. Action 1—Supervise. Monitor the operation to ensure:

- 48.1. The controls are effective and remain in place.
- 48.2. Changes which require further risk management are identified.
- 48.3. Action is taken when necessary to correct ineffective risk controls and reinitiate the risk management steps in response to new hazards.
- 48.4. Anytime the personnel, equipment, or mission taskings change or new operations are anticipated in an environment not covered in the initial risk management analysis, the risks and control measures should be reevaluated. The best tool for accomplishing this is change analysis.
- 48.5. Successful mission performance is achieved by shifting the cost versus benefit balance more in favor of benefit through controlling risks. By using ORM whenever anything changes, we consistently control risks, those known before an operation and those that develop during an operation. Being proactive and addressing the risks before they get in the way of mission accomplishment saves resources, enhances mission performance, and prevents the mishap chain from ever forming.

49. Action 2—Review. The process review must be systematic. After assets are expended to control risks, then a cost benefit review must be accomplished to see if risk and cost are in balance. Any changes in the system (the 5-M model, and the flow charts from the earlier steps provide convenient benchmarks to compare the present system to the original) are recognized and appropriate risk management controls are applied.

49.1. To accomplish an effective review, supervisors need to identify whether the actual cost is in line with expectations. Also the supervisor will need to see what effect the control measure has had on mission performance. It will be difficult to evaluate the control measure by itself so focus on the aspect of mission performance the control measure was designed to improve.

49.2. A review by itself is not enough, a mission feedback system must be established to ensure that the corrective or preventative action taken was effective and that any newly discovered hazards identified during the mission are analyzed and corrective action taken. When a decision is made to assume risk, the factors (cost versus benefit information) involved in this decision should be recorded. When a mishap or

negative consequences occur, proper documentation allows for the review of the risk decision process to see where errors might have occurred or if changes in the procedures and tools lead to the consequences. Secondly, it is unlikely that every risk analysis will be perfect the first time. When risk analyses contain errors of omission or commission, it is important that those errors be identified and corrected. Without this feedback loop, we lack the benefit of knowing if the previous forecasts were accurate, contained minor errors, or were completely incorrect.

49.3. Measurements are necessary to ensure accurate evaluations of how effectively controls eliminated hazards or reduced risks. After action reports, surveys, and in progress reviews provide great starting places for measurements. To be meaningful, measurements must quantitatively or qualitatively identify reductions of risk, improvements in mission success, or enhancement of capabilities.

50. Action 3—Feedback. A review by itself is not enough, a mission feedback system must be established to ensure that the corrective or preventative action taken was effective and that any newly discovered hazards identified during the mission are analyzed and corrective action taken. Feedback informs all involved as to how the implementation process is working, and whether or not the controls were effective. Whenever a control process is changed without providing the reasons, co-ownership at the lower levels is lost. The overall effectiveness of these implemented controls must also be shared with other organizations that might have similar risks to ensure the greatest possible number of people benefit. Feedback can be in the form of briefings, lessons learned, cross-tell reports, benchmarking, database reports, etc. Without this feedback loop, we lack the benefit of knowing if the previous forecasts were accurate, contained minor errors, or were completely incorrect.

51. Monitoring the Effectiveness of Implementation. This aspect of the supervise and review step should be routine. Periodically monitor the progress of implementation against the planned implementation schedule that should have been developed during the third and fifth ORM steps. Take action as necessary to maintain the planned implementation schedule or make adjustments as necessary.

52. Monitoring the Effectiveness of Risk Controls. If the risk control has been well designed, it will favorably change either physical conditions or personnel behavior during the conduct of an operation. The challenge is to determine the extent to which this change is taking place. If there has been no change or only minor change, the risk control is possibly not worth the resources expended on it. It may be necessary to modify it or even rescind it. At first thought it may seem obvious that we need only determine if the number of mishaps or other losses has decreased. This is only practical at higher levels of command, typically wing level or higher, because accurate measurement of changes in actual losses almost always requires large amounts of exposure (man-hours, flight hours, miles driven, etc.) only found at those levels of command. Even at those levels of command where we have sufficient exposure to validly assess actual losses, it may be a year or more before significant changes actually occur. This is too long to wait to assess the effectiveness of risk controls. Too much effort may have been invested before we can determine the impact of our proposals. We need to know how we are doing much sooner. If we can't efficiently measure effectiveness using mishaps, how can we do it? The answer is to directly measure the degree of risk present in the system.

52.1. Direct Measures of Behavior. When the target of a risk control is behavior, it is possible to actually sample behavior changes in the target group. The results of an effort to get personnel to wear seat belts,

for example, can be assessed by making a number of observations of the use of restraints before initiating the seat belt program and a similar sample after. The change, if any, is a direct measure of the effectiveness of the risk control. The sample would establish the % of personnel using belts as a percentage of total observations. Subsequent samples would indicate our success in sustaining the impact of the risk control.

52.2. Direct Measures of Conditions. In the exact same manner as described in 52.1., it is possible to assess the changes in physical conditions in the workplace. For example, the amount of foreign objects found on the flight line can be assessed before and after a risk control initiative aimed at reducing foreign object damage.

52.3. Measures of Attitudes. Surveys can also assess the attitudes of personnel toward risk-related issues. While constructing survey questions is technical and must be done right, the Air Force often conducts surveys and it may be possible to integrate questions in these surveys, taking advantage of the experts who manage these survey processes. Nevertheless, even informal surveys taken verbally in very small organizations will quickly indicate the views of personnel.

52.4. Measures of Knowledge. Some risk controls are designed to increase knowledge of some hazard or of hazard control procedures. A short quiz, perhaps administered during a safety meeting or standdown day can effectively assess the levels of knowledge before and after a training risk control is initiated.

52.5. Safety and Other Loss Control Audit Procedures. Programmatic and procedural risk control initiatives (such as revisions to standard operating procedures) can be assessed through various kinds of audits. The typical audit involves a standard set of questions or statements reflecting desirable standards of performance against which actual operating situations are compared.

53. Evaluating Overall Organization Performance. If the organization is large enough to accumulate enough exposure (100,000 flight hours, 200,000 personnel hours, 1,000,000 miles driven) to have statistically valid rates, then rates are an excellent results measure of organization performance. Obviously most organizations do not have this much exposure and valid rates cannot be calculated on an annual basis. Even in those organizations that do accumulate the exposure necessary to calculate valid rates, it is important to use them properly. Because of their statistical nature there is considerable normal variation in rates. They go up and down for no other reason than the normal variation in the occurrence of events. It is important not to let this normal variation be interpreted as meaningful. When mishap numbers or rates increase or decrease, as an example, it is important to have an individual with statistical expertise assess the significance of the changes. Normally the servicing safety office can provide this service. In smaller organizations in which rates are not a useful tool, it is possible to assess overall organization risk management success using a cross section of indicators like those described in paragraph 52. See attachment 7 for a more detailed explanation. Even larger organizations, need such measures of process effectiveness to augment the use of mishap rates or numbers as performance result measures.

Section I—Conclusion

54. Operational risk management provides a logical and systematic means of identifying and controlling risk. Operational risk management is not a complex process, but it does require individuals, supervisors, and leaders to support and implement the basic principles on a continuing basis. Operational risk management offers individuals and organizations a powerful tool for increasing effectiveness and reducing mishaps. The ORM process is accessible to and usable by everyone in every conceivable setting or scenario. It ensures that all Air Force personnel will have a voice in the critical decisions that determine success or failure in all our missions and activities, on- and off-duty. Properly implemented, ORM will always enhance mission performance.

FRANCIS C. GIDEON, JR., Major General, USAF
Chief of Safety

Attachment 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

References

AFI 91-213, *Operational Risk Management (ORM) Program*

AFI 91-204, *Safety Investigations and Reports*

Abbreviations and Acronyms

AFI—Air Force Instruction

Avg—Average

BOT—Behavior observation tool

CMDR—Commander

CSAF—Chief of Staff of the Air Force

DoD—Department of Defense

E—Exposure

EH—Extremely high

ETBA—Energy trace and barrier analysis

F—Function

FCIF—Flight crew information file

Flt—Flight

FMEA—Failure modes and effects analysis

FTA—Fault tree analysis

Gen—General

H—High

Hazmat—Hazardous material

HAZOP—Hazard operability

Hrs—Hours

ID—Identification

IG—Inspector General

L—Low

LTA—Less than adequate

JHA—Job hazard analysis

JSA—Job safety analysis

M—Medium

MAJCOM—Major command

Max—Maximum

MES—Multilinear events sequence

MORT—Management oversight and risk tree

NCO—Noncommissioned Officer

NOTAM—Notice to airmen

OA—Operations analysis

OI—Operations instruction

ORM—Operational Risk Management

OSHA—Occupational Safety and Health Administration

P—Probability

PHA—Preliminary hazard analysis

PHL—Preliminary hazard list

QA—Quality assurance

RAC—Risk assessment code

RIMS—Risk information management system

ROE—Rules of engagement

S—Severity

SOP—Standard operating procedure

STEP—Sequential time event plot

TO—Technical order

TRA—Training realism assessment

US—United States

USAF—United States Air Force

WWW—World-wide web

Terms

Exposure—The number of personnel or resources affected by a given event or, over time, by repeated events. This can be expressed in terms of time, proximity, volume, or repetition. This parameter may be included in the estimation of severity or probability, or considered separately.

Gambling—Making risk decisions without reasonable or prudent assessment or management of the risks involved.

Hazard—Any real or potential condition that can cause mission degradation, injury, illness, death to personnel or damage to or loss of equipment or property.

Mishap—An unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property.

Operator— “. . . a military or civilian member of our service who is experienced in the employment and doctrine of air and space power” (Gen. Ronald R. Fogleman, former CSAF).

Probability—The likelihood that an individual event will occur.

Risk—An expression of consequences in terms of the probability of an event occurring, the severity of the event and the exposure of personnel or resources to potential loss or harm. A general expression of risk as a function of probability, severity, and exposure can be written as: $\text{Risk} = f(P, S, E)$.

Risk Assessment—The process of detecting hazards and their causes, and systematically assessing the associated risks.

Risk Control—An action designed to reduce risk by lowering the probability of occurrence and/or decreasing the severity of an identified hazard.

Severity—The expected consequences of an event in terms of mission impact, injury, or damage.

System—A composite, at any level of complexity, of personnel, procedures, materials, tools, equipment, facilities, and software. The elements of this composite entity are used together in the intended operational or support environment to perform a given task or achieve a specific mission requirement.

Attachment 2

HAZARD IDENTIFICATION TOOLS, DETAILS AND EXAMPLES

SECTION A2.A. PRIMARY HAZARD IDENTIFICATION TOOLS

A2.A.1. The seven tools that follow are considered the “primary” or basic set of hazard ID tools to be applied on a day-to-day basis in organizations at levels down to and including non-supervisory personnel. These tools have been chosen for the following reasons:

A2.A.1.1. They are simple to use, requiring little if any training.

A2.A.1.2. They have been proven effective.

A2.A.1.3. Widespread application has demonstrated they can and will be used by operators and will consistently be perceived as positive.

A2.A.1.4. As a group, they complement each other, blending the intuitive and experiential with the more structured and rigorous.

A2.A.1.5. They are well supported with worksheets and job aids.

A2.A.1.6. Collectively they will support up to and including a deliberate level of risk management application.

A2.A.2. In an organization with a mature ORM culture, the use of these tools by all personnel will be regarded as the natural course of events. The cultural norm will be “Why would I even consider exposing myself and others to the risks of this activity before I have identified the hazards involved using the best procedures available?” The following pages describe each tool using a standard format with models and examples.

A2.A.3. THE OPERATIONS ANALYSIS AND FLOW DIAGRAM

A2.A.3.1. FORMAL NAME. The operations analysis

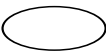




A2.A.3.2. ALTERNATIVE NAMES. The flow diagram, flow chart, operation timeline

A2.A.3.3. PURPOSE. The operations analysis (OA) provides an itemized sequence of events or a diagram (in the case of the flow diagram) depicting the major events of an operation. The purpose of this flow of events is to assure that all elements of an operation are evaluated for potential sources of risk. This overcomes a major weaknesses of traditional risk management which tends to immediately focus effort on one or two aspects of an operation that intuitively are identified as risky to the exclusion of other aspects that may actually be riskier. The operations analysis also guides the allocation of risk management resources over time as an operation unfolds event by event in a systematic manner.

A2.A.3.4. APPLICATION. The operations analysis or flow diagram is used in virtually all risk management applications to include the most time critical. It responds to the key risk management question “What am I facing here and from where can risk arise?”

A2.A.3.5. METHOD. Whenever possible the operations analysis is taken directly from the product produced by the personnel planning an operation. It is difficult to imagine planning an operation without identifying the key events in a time sequence. If for some reason such a list is not available, then the analyst creates it using the best available understanding of the operation. A key issue is the level of detail. The best practice is to break the operation down into time sequenced segments that have strongly related tasks and activities. This is normally well above the detail of individual tasks. The examples provided in paragraph A2.A.3.8. are good guides to the level of detail appropriate. It may be appropriate to break aspects of an operation that are obviously higher risk down into more detail than less risky areas. The output product of an OA is the major events of an operation in sequence with or without time checks. An alternative to the operations analysis is the flow diagram. The flow diagram converts the list of events of the operations analysis into a diagram using the well established procedures of the flow diagram. Commonly used symbols are provided at Figure A2.1. Consider putting the steps of the process on index cards or stick back note paper. This lets you rearrange the diagram without erasing and redrawing, making it easy to reconfigure the diagram and encouraging contributions.

Figure A2.1. Example Flow Chart Symbols.

SYMBOL	REPRESENTS	EXAMPLE
	START	RECEIVE TASKING BEGIN TRIP OPEN CHECKLIST
	ACTIVITY	MISSION PLANNING START CAR STEP ONE IN CHECKLIST
	DECISION POINT (OR)	YES/NO APPROVE/DISAPPROVE PASS/FAIL
	FORK/SPLIT (AND)	PREPOSITION VEHICLES AND SUPPLIES RELEASE CLUTCH AND PRESS ACCELERATOR OBSERVE FLIGHT CONTROLS WHILE MOVING STICK
	END	FINAL REPORT ARRIVE AT DESTINATION AIRCRAFT ACCEPTED

A2.A.3.6. **RESOURCES.** The key resource for the operations analysis is the mission planners. Using their mission layout will facilitate the integration of risk controls in the main operational plan and will virtually eliminate the expenditure of duplicative resources on this key aspect of hazard identification.

A2.A.3.7. **COMMENTS.** Look back on your own experience. How many times have you been surprised or seen others surprised because they overlooked possible sources of problems. The operations analysis is the key to minimizing this source of failure.

A2.A.3.8. **EXAMPLES.** Following are examples of operations analyses and flow diagrams illustrating variations of this tool.

A2.A.3.8.1. The first example (Figure A2.2) is of a major operational activity - deployment of a large element to foreign airbase. The initial analysis may be at a relatively macro level, listing the major events in the deployment scenario.

Figure A2.2. Example Macro Events.

DEPLOYMENT TO A FRIENDLY COUNTRY'S AIRBASE
<ol style="list-style-type: none"> 1. Contingency Concept Developed 2. Planning Initiated 3. Deployment Initiated 4. Operations Initiated 5. Operations Are Extended 6. Contingency: Additional Unit Deployed To Base 7. Contingency: A Security Threat 8. Operations Cease 9. Redeployment 10. Arrive At Home Base - Normal Status

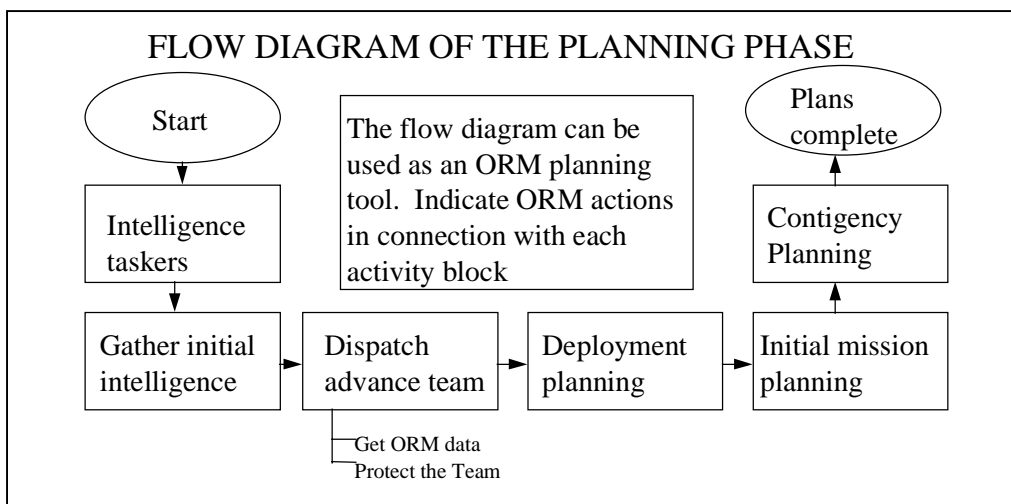
A2.A.3.8.2. Any one event of the above sequence may be examined in more detail if this is judged useful by developing an operations analysis of the events within that particular event. For example, the planning phase can be selected for more detailed examination as illustrated in Figure A2.3 below.

Figure A2.3. Example Planning Phase Events.



A2.A.3.8.3. If more detail and more structured examination of the operational flow is desired the flow diagram can be used. The flow diagram will add information through the use of graphic symbols and will add rigor to the process. A flow diagram of the planning phase above might be developed as illustrated in Figure A2.4 below.

Figure A2.4. Example Flow Diagram.



A2.A.4. THE PRELIMINARY HAZARD ANALYSIS

A2.A.4.1. FORMAL NAME. Preliminary Hazard Analysis

A2.A.4.2. ALTERNATIVE NAMES. The PHA, Preliminary Hazard List, the PHL

A2.A.4.3. PURPOSE. The PHA provides an initial overview of the hazards present in the overall flow of the operation. It provides a hazard assessment that is broad, but usually not deep. The key idea of the PHA is to at least briefly consider risk in every aspect of an operation. The PHA helps overcome the strong tendency in traditional, intuitive risk management to focus immediately on risk in one aspect of an operation. This often leads to overlooking more serious issues hidden in other aspects of the operation. The PHA will often serve as the total hazard ID process when risk is low or routine. In higher risk operations, it serves to focus and prioritize follow-on hazard analyses by displaying the full range of risk issues.

A2.A.4.4. APPLICATION. The PHA is used in virtually all risk management applications except the most time critical. Its broad scope is an excellent guide to the identification of issues that may require more detailed hazard ID tools.

A2.A.4.5. METHOD. The PHA/PHL is usually based on the operations analysis or flow diagram. The analyst or group takes each event in turn from the operations analysis. They apply their experience and intuition, use reference publications and standards of various kinds, and consult with personnel who may have useful input. The extent of the effort is dictated by resource and time limitations and by the estimate of the degree of overall hazard inherent in the operation. Hazards that are detected are often listed directly on a copy of the operations analysis as shown at Figure A2.5. Alternatively, a more formal PHA format such as the one at Figure A2.6 can be used. The output of the PHA/PHL is either hazards noted on the operations analysis or the more formal completed PHA worksheet listing all of the hazards of each phase of the operation. The completed PHA is used to identify hazards requiring more in-depth hazard identification or it may lead directly to the remaining five steps of the ORM process if hazard levels are judged to be low. A key to an effective PHA/PHL is to assure that all events of the operation are covered.

Figure A2.5. Building The Pha Directly From The Operations Analysis Flow Diagram.

Operational Phase	Hazards
List the operational phases vertically down the page. Be sure to leave plenty of space on the worksheet between each phase to allow several hazards to be noted for each phase.	List the hazards noted for each operational phase here. Strive for detail within the limits imposed by the time you have set aside for this tool.

A2.A.4.6. RESOURCES. The two key resources for the PHA are the expertise of personnel actually experienced in the operation and the body of regulations, standards, technical orders (TOs) and operations instructions (OIs) that may be available. The PHA can be accomplished in small groups to broaden the

base of experience and expertise. Of course a copy of a quality PHA accomplished for an earlier, similar operation will really kick-start the process.

A2.A.4.7. **COMMENTS.** The PHA is relatively easy to use and takes very little time. Its significant power to impact risk arises from the forced consideration of risk in **all** phases of an operation. This means that a key to success is to link the PHA closely to the operations analysis.

A2.A.4.8. **EXAMPLES.** The following (Figure A2.6) is an example of a PHA.

Figure A2.6. Example PHA.

<p>MOVING A HEAVY PIECE OF EQUIPMENT. The example below uses an operations analysis for moving a heavy piece of equipment as the start point and illustrates the process of building the PHA direct from the operations analysis.</p> <p>Operation: Move a 3 ton machine from one building to another</p> <p>Start point: The machine is in its original position in building A</p> <p>End point: The machine is in its new position in building B</p>	
ACTIVITY / EVENT	HAZARD
Raise the machine to permit positioning of the forklift	Machine overturns due to imbalance Machine overturns due to failure of lifting device Machine drops on person or equipment due to failure of lifting device or improper placement (person or lifting device) Machine strikes overhead obstacle Machine is damaged by the lifting process
Position the forklift	Forklift strikes the machine Forklift strikes other items in the area
Lift the machine	Machine strikes overhead obstacle Lift fails due to mechanical failure (damage to machine, objects, or people) Machine overturns due to imbalance
Move machine to the truck	Instability due to rough surface or weather condition Operator error causes load instability The load shifts
Place machine on the truck	Improper tiedown produces instability Truck overloaded or improper load distribution
Drive truck to building B	Vehicle accident during the move Poor driving technique produces instability Instability due to road condition
Remove machine from the truck	Same factors as “Move it to the truck”
Place the machine in proper position in building B	Same factors as “Raise the machine” except focused on lowering the machine.

A2.A.5. THE WHAT IF TOOL

A2.A.5.1. FORMAL NAME. The “what if” tool

A2.A.5.2. ALTERNATIVE NAMES. None.

A2.A.5.3. PURPOSE. The what if tool is one of the most powerful hazard ID tools. As in the case of the scenario process tool, it is designed to add structure to the intuitive and experiential expertise of operational personnel. The what if tool is especially effective in capturing hazard data about failure modes. It is somewhat more structured and rigorous than the PHA. Because of its ease of use, it is probably the single most practical and effective tool for use by operational personnel.

A2.A.5.4. APPLICATION. Because of its ease of use and effectiveness in identifying hazards, the what if tool should be used in most hazard identification applications to include many time critical applications. A classic use of the what if tool is as the first tool used after the operations analysis and the PHA. For example, the PHA reveals an area of hazard that needs additional investigation. Probably the best single tool to further investigate that area will be the what if tool. The user will home-in on the particular area of concern, add detail to the operations analysis in this area and then use the what if procedure to really dig out the hazards.

A2.A.5.5. METHOD.

A2.A.5.5.1. Ensure participants have a thorough knowledge of the anticipated flow of the operation.

A2.A.5.5.2. Visualize the expected flow of events in time sequence from the beginning to the end of the operation.

A2.A.5.5.3. Select a segment of the operation on which to focus.

A2.A.5.5.4. Visualize the selected segment with "Murphy" injected. Make a conscious effort to visualize failures. Ask "what if various failures occurred or problems arose"?

A2.A.5.5.5. Add potential failures and their causes to your hazard list and assess them based on probability and severity.

A2.A.5.5.6. The "What-If" analysis can be expanded to further explore the hazards in an operation by using scenario thinking. To use scenario thinking, develop short scenarios which reflect the worst credible outcome from compound effects of multiple hazards in the operation.

A2.A.5.5.7. Follow the guidelines below in writing scenarios:

A2.A.5.5.7.1. Target length is 5 or 6 sentences, 60 words

A2.A.5.5.7.2. Don't dwell on grammatical details

A2.A.5.5.7.3. Include elements of man, machine, media, management

A2.A.5.5.7.4. Start with history but sanitize

A2.A.5.5.7.5. Encourage imagination and intuition

A2.A.5.5.7.6. Carry the scenario to the worst credible outcome

A2.A.5.5.7.7. Use a single person or group to edit

A2.A.5.6. RESOURCES. A key resource for the what if tool is the operations analysis. It may be desirable to add detail to the operations analysis in the area to be targeted by the what if analysis. However, in most cases the operations analysis can be used as is. The what if tool is specifically designed to be used by personnel actually involved in an operation. Therefore, the most critical what if resource is

the involvement of operators and their first line supervisors. Because of its effectiveness, dynamic character, and ease of application, these personnel are generally quite willing to support the what if process.

A2.A.5.7. COMMENTS. The what if tool is so effective that the Occupational Safety and Health Administration (OSHA) designated it one of six tools from which activities facing catastrophic risk situations must choose under the mandatory hazard analysis provisions of the process safety standard.

A2.A.5.8. EXAMPLES. Following (Figure A2.7) is an extract from the typical output from the what if tool.

Figure A2.7. Example What If Output.

<p>Situation: Picture a group of 3 operating employees informally applying the round-robin procedure for the what if tool to a mission to move a multi-ton machine from one location to another. A part of the discussion might go as follows:</p>
<p>Joe: What if the machine tips over and falls breaking the electrical wires that run within the walls behind it? Bill: What if it strikes the welding manifolds located on the wall on the west side? <i>(This illustrates “piggybacking” as Bill produces a variation of the hazard initially presented by Joe).</i> Mary: What if the floor fails due to the concentration of weight on the base of the lifting device? Joe: What if the point on the machine used to lift it is damaged by the lift? Bill: What if there are electrical, air pressure hoses, or other attachments to the machine that are not properly neutralized? Mary: What if lock out/tag out is not properly applied to energy sources servicing the machine? and so on....</p>
<p>Note: It is important to capture each what if on a worksheet. When the ideas are exhausted or time runs out, the hazards are grouped into similar categories. The list above for example might be broken out as follows:</p> <p>Group 1: Machine falling hazards Group 2: Weight induced failures Group 3: Machine disconnect and preparation hazards</p> <p>These related groups of hazards are then subjected to the remaining five steps of the ORM process.</p>

A2.A.6. THE SCENARIO PROCESS TOOL

A2.A.6.1. FORMAL NAME. The scenario process tool

A2.A.6.2. ALTERNATIVE NAMES. The mental movie tool.

A2.A.6.3. PURPOSE. The scenario process tool is a time tested procedure to identify hazards by visualizing them. It is designed to capture the intuitive and experiential expertise of personnel involved in planning or executing an operation in a somewhat systematic and structured way. In other words, it adds increased rigor to the intuitive and experiential processes of traditional risk management. It is especially useful in connecting various individual hazards into scenarios that might actually occur. It is also used to visualize the worst credible outcome of one or more related hazards and is therefore an important contributor to the risk assessment process.

A2.A.6.4. APPLICATION. Because of its simplicity and power to identify hazards, the scenario process tool should be used in most hazard identification applications to include some time critical applications. In the time critical mode, one of the few practical tools is the scenario process tool in which the user quickly forms a “mental movie” of the flow of events immediately ahead and the associated potential hazards.

A2.A.6.5. METHOD. The user of the scenario process tool attempts to literally visualize the flow of events in an operation. This is often described as constructing a “mental movie”. It is often effective to literally close the eyes, relax and let the images flow. Usually the best procedure is to use the flow of events established in the operations analysis. An effective tool is to actually visualize the flow of events twice. The first time see the events as they are intended to flow. The next time inject “Murphy” at every possible event. As hazards are visualized, they are recorded for further action. Some good guidelines for the development of scenarios are as follows:

A2.A.6.5.1. Limit them to 60 words or less.

A2.A.6.5.2. Don’t get tied up in grammatical excellence (in fact they don’t have to be recorded at all).

A2.A.6.5.3. Use historical experience but sanitize to avoid embarrassing anyone.

A2.A.6.5.4. Encourage imagination (this helps identify risks that have not been previously encountered).

A2.A.6.5.5. Carry scenarios to the worst credible event.

A2.A.6.6. RESOURCES. The key resource for the scenario process tool is the operations analysis. It provides the script for the flow of events that will be visualized. Because of its simplicity, a key resource often available for the scenario process tool are the operational personnel leading or actually performing the mission. This tool is often entertaining, dynamic and motivating for even the most junior personnel in the organization.

A2.A.6.7. COMMENTS. A special value of the scenario process tool is its ability to link two or more individual hazards developed using other tools into a mission relevant scenario.

A2.A.6.8. EXAMPLES. Following are two examples (Figures A2.8 and A2.9) of how the scenario process tool might be used in an operational situation.

Figure A2.8. Example Deployment Scenario.

FROM DEPLOYMENT EXAMPLE: During a security drill a vehicle carrying 10 personnel from the rapid reaction force turns a corner at high speed and plows into a troop formation formed in the roadway (lack of space anywhere else). One person is killed and 15 are injured.

Figure A2.9. Example Machine Movement Scenario.

FROM MACHINE MOVEMENT EXAMPLE: As the machine was being jacked-up to permit placement of the forklift, the fitting that was the lift point on the machine broke. The machine tilted in that direction and fell over striking the nearby wall. This in turn broke a fuel gas line in the wall. The gas was turned off as a precaution, but the blow to the metal line caused the valve to which it was attached to break, releasing gas into the atmosphere. The gas quickly reached the motor of a nearby fan (not explosion proof) and a small explosion followed. Several personnel were badly burned and that entire section of the shop was badly damaged. The shop was out of action for 3 weeks.

A2.A.7. THE LOGIC DIAGRAM

A2.A.7.1. FORMAL NAME. The logic diagram

A2.A.7.2. ALTERNATIVE NAMES. The logic tree

A2.A.7.3. PURPOSE. The logic diagram is intended to provide the maximum structure and detail among the primary hazard ID procedures. Its graphic structure is an excellent means of capturing and correlating the hazard data produced by the other primary tools. Because of its graphic display, it can also be an effective hazard briefing tool. The more structured and logical nature of the logic diagram adds substantial depth to the hazard ID process to complement the other more intuitive and experiential tools. Finally, an important purpose of the logic diagram is to establish the connectivity and linkages that often exist between hazards. It does this very effectively through its tree-like structure.

A2.A.7.4. APPLICATION. Because it is more structured, the logic diagram requires more time and effort. Following the principles of ORM, its use will be more limited than the other primary tools. This means limiting its use to higher risk issues. By its nature it is also most effective with more complicated operations in which several hazards may be interlinked in various ways. Because it is a little more complicated than the other primary tools, it requires somewhat more practice and may not appeal to all operational personnel. However, in an organizational climate committed to ORM excellence, the logic diagram will be a welcomed and often used addition to the hazard ID armory.

A2.A.7.5. METHOD. There are three major types of logic diagrams. These are the:

A2.A.7.5.1. Positive diagram. This variation is designed to highlight the factors that must be in place if risk is to be effectively controlled in the operation. It works from a safe outcome back to the factors that must be in place to produce it.

A2.A.7.5.2. Event diagram. This variation focuses on an individual operational event (often a failure identified using the what if tool) and examines the possible consequences of the event. It works from an event that may produce risk and shows what the loss outcomes of the event may be.

A2.A.7.5.3. Negative diagram. This variation selects a loss event and then analyzes the various hazards that could combine to produce that loss. It works from an actual or possible loss and identifies what factors could produce it.

A2.A.7.5.4. All of the various logic diagram options can be applied either to an actual operating system or one being planned. Of course, the best time for application is in the planning stages of the operational lifecycle. All of the logic diagram options begin with a top block. In the case of the positive diagram, this is a desired outcome; in the case of the event diagram, this is an operations event or contingency possibility; in the case of the negative diagram, it is a loss event. When working with positive diagram or negative diagram, the user then reasons out the factors that could produce the top event. These are entered on the next line of blocks. With the event diagram, the user lists the possible results of the event being analyzed. The conditions that could produce the factors on the second line are then considered and they are entered on the third line. This process can go to several levels, but the utility of going beyond 3 or

4 levels is usually very limited. The goal is to be as logical as possible when constructing logic diagrams, but it is more important to keep the hazard ID goal in mind than to construct a masterpiece of logical thinking. Therefore, a logic diagram should be a worksheet with lots of changes and variations marked on it. Logic diagrams can be completed by a single individual, but with the additional of a chalkboard or flip chart, it also becomes an excellent group tool. Figure A2.10 below is a generic diagram followed by a simplified example of each of the types of logic diagrams (Figures A2.11, A2.12 and A2.13) clearly showing the concept of each.

Figure A2.10. Generic Logic Diagram.

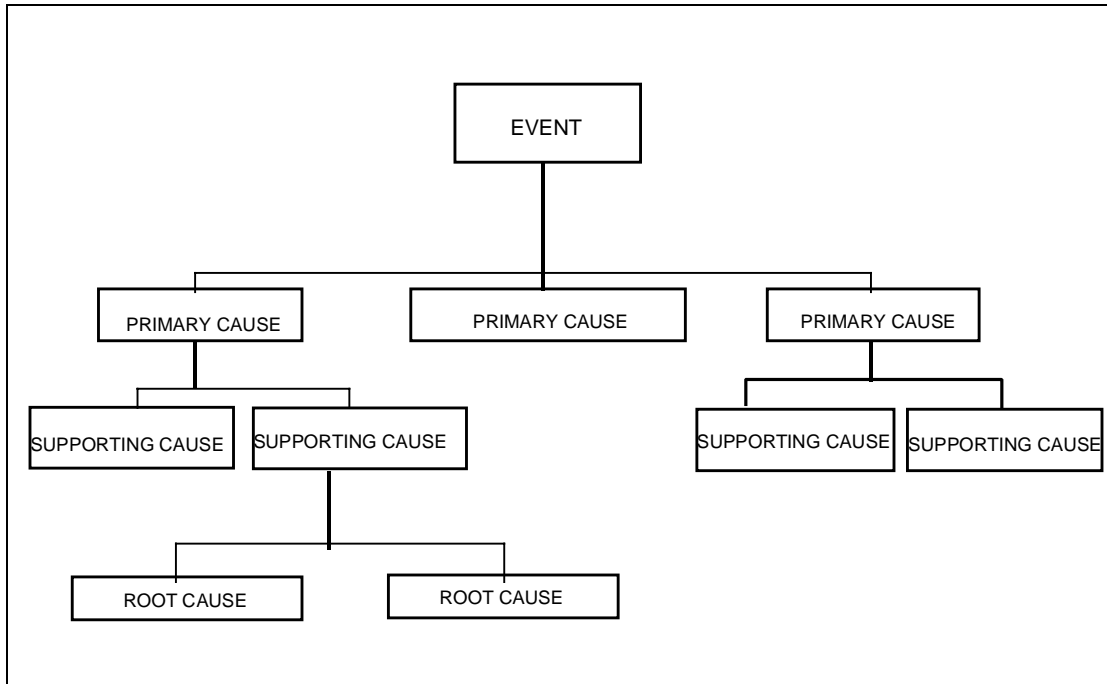


Figure A2.11. Positive Event Logic Diagram.

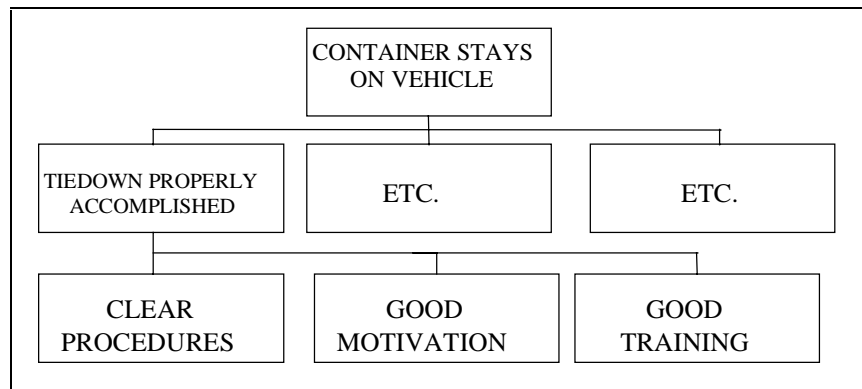


Figure A2.12. Risk Event Diagram.

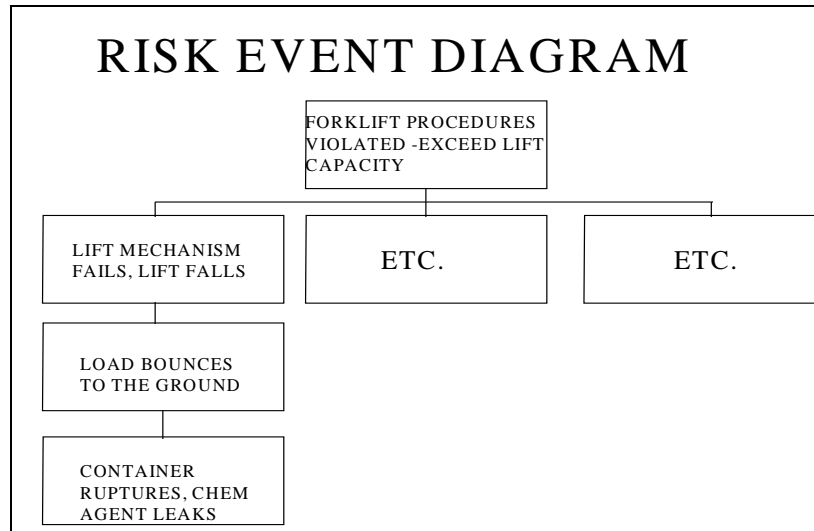
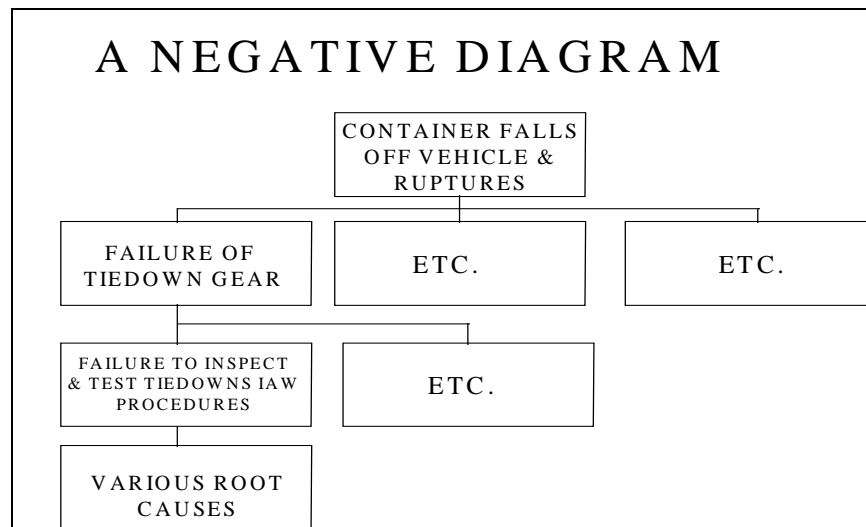


Figure A2.13. Negative Event Logic Diagram.

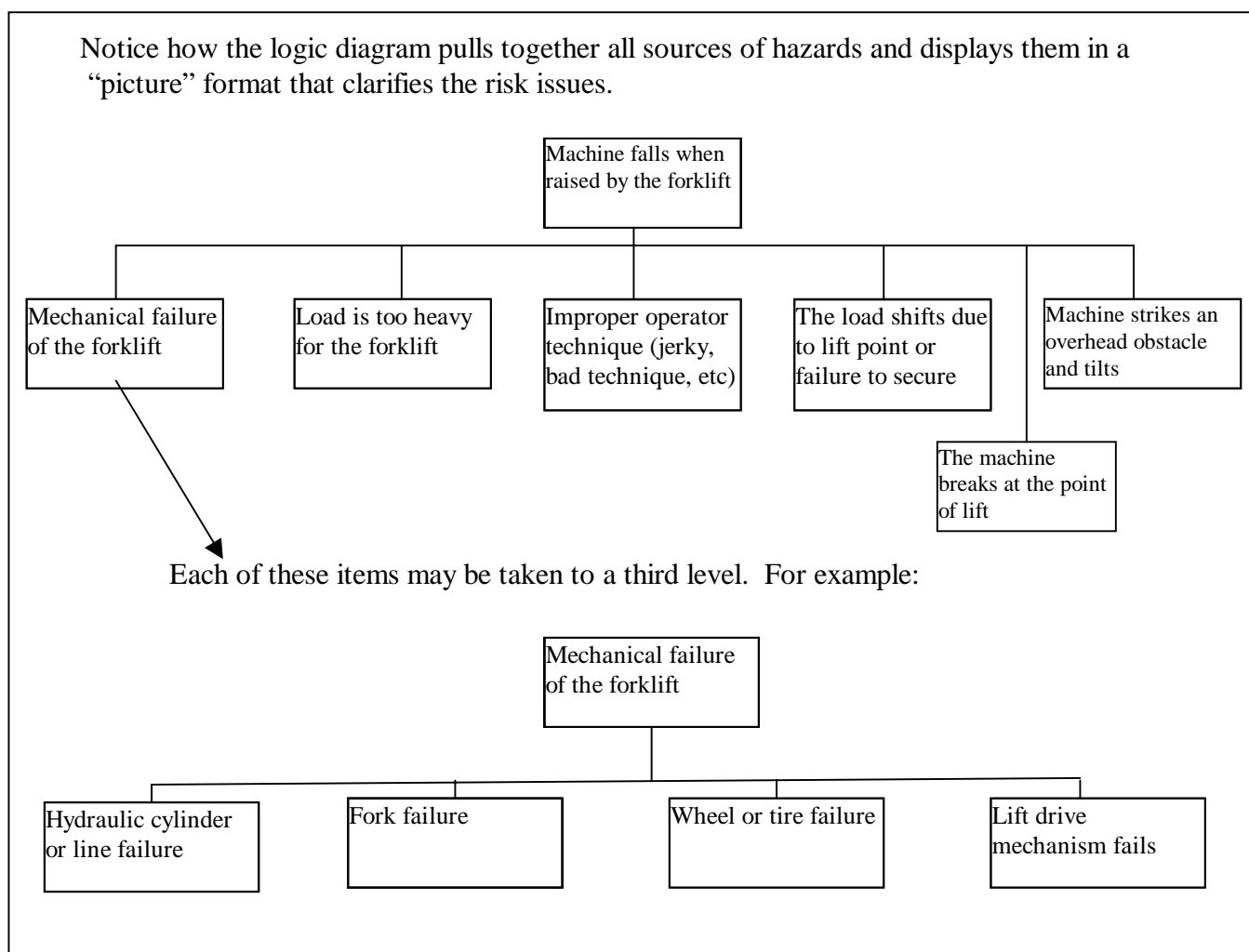


A2.A.7.6. RESOURCES. A key resource for the logic diagram is all of the other primary tools. The logic diagram can correlate hazards generated by the other tools. If available, a safety professional may be an effective facilitator for the logic diagram process.

A2.A.7.7. COMMENTS. The logic diagram is the most comprehensive tool available among the primary procedures. Compared to traditional approaches to hazard ID, it will substantially increase the quantity and quality of hazards identified. Its versatility, arising from its many variations, also make it an essential weapon in the operational leader's ORM toolbox.

A2.A.7.8. EXAMPLE. Figure A2.14 illustrates how a negative diagram could be constructed when moving a heavy piece of equipment.

Figure A2.14. Example Negative Diagram.



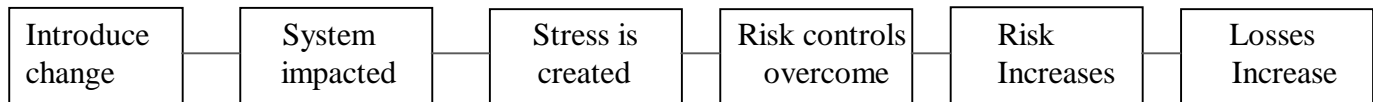
A2.A.8. THE CHANGE ANALYSIS

A2.A.8.1. FORMAL NAME. The change analysis

A2.A.8.2. ALTERNATIVE NAMES. None

A2.A.8.3. PURPOSE. Historically change has been an important source of risk in operational processes. Figure A2.15 illustrates this causal relationship.

Figure A2.15. Change Causation.



A2.A.8.3.1. Some of these changes are planned, but many occur incrementally over time without any intentional or conscious direction. The change analysis is intended to analyze the hazard implications of either planned or unplanned changes. Properly used, the change analysis allows the risk management process to focus only on the changed aspects of the operation. This eliminates the need to reanalyze the total operation just because a change has occurred in one area. The change analysis is also used to detect the occurrence of change. By periodically systematically comparing current procedures with previous procedures, unplanned changes are identified and clear defined. Finally, change analysis is an important mishap investigation tool. Because many mishaps are due to the injection of change into systems, an important investigative objective is to identify these changes using the change analysis procedure.

A2.A.8.4. APPLICATION. Change analysis should be routinely used in the following situations.

A2.A.8.4.1. Whenever significant changes are planned in operations in which there is significant mission risk of any kind. A typical example is the decision to conduct a certain type of operation at night that has only been done in daylight previously.

A2.A.8.4.2. Periodically, perhaps once a year, in any mission important operation to detect the occurrence of unplanned changes. A typical example is the many different types of maintenance procedures.

A2.A.8.4.3. As a mishap investigation tool.

A2.A.8.4.4. As the only hazard ID tool required when an operational area has been subjected to in-depth hazard analysis. The change analysis tool will reveal if any elements exist in the current operation that were not considered in the previous in-depth analysis.

A2.A.8.5. METHOD. The change analysis is best accomplished using a format such as the sample worksheet shown at Figure A2.16. The factors in the column on the left side of this tool are intended as a comprehensive change checklist.

Figure A2.16. Sample Change Analysis Worksheet.

Target: _____ Date: _____				
FACTORS	EVALUATED SITUATION	COMPARABLE SITUATION	DIFFERENCE	SIGNIFICANCE
WHAT Objects Energy Defects Protective Devices WHERE On the object In the process Place WHEN In time In the process WHO Operator Fellow worker Supervisor Others TASK Goal Procedure Quality WORKING CONDITIONS Environmental Overtime Schedule Delays TRIGGER EVENT MANAGERIAL CONTROLS Control Chain Hazard Analysis Monitoring Risk Review				
<p>To use the worksheet: The user starts at the top of the column and considers the current situation compared to a previous situation and identifies any change in any of the factors. When used in a mishap investigation, the mishap situation is compared to a previous baseline. The significance of detected changes can be evaluated intuitively or they can be subjected to what if, logic diagram, or scenario, other specialized analyses.</p>				

A2.A.8.6. RESOURCES. A key resource for the change analysis tool is experienced operational personnel who have long term involvement in an operational process. These personnel must help define the “comparable situation.” Another important resource is the documentation of process flows and task analyses. Large numbers of such analyses have been completed in recent years in connection with quality

improvement and reengineering projects. These materials are excellent definitions of the baseline against which change can be evaluated.

A2.A.8.7. COMMENTS. The change analysis is one of the most important hazard analysis tools. In organizations with mature ORM processes, most, if not all, higher risk activities will have been subjected to thorough ORM applications and the resulting risk controls will have been incorporated into operational guidance. In this situation, the vast majority of day-to-day ORM activity is the application of change analysis to determine if this particular operation has any unique aspects that have not been previously analyzed. Only if specific changes are detected will it be necessary to apply any ORM procedures. If there is no change, optimum procedures will already have been fully integrated in the established operational guidance.

A2.A.8.8. EXAMPLES. An example of a change analyses is illustrated at Figures A2.17 and A2.18.

Figure A2.17. Example of Change Analysis.

Situation: The DO of an Air Force Reserve flying organization has observed evidence of what he considers “loose” flying over the last several days. He decides to use a change analysis to assess changes in the unit that may have led to this deterioration in flying performance. He uses the change analysis worksheet illustrated earlier (Figure A2.16) to make this assessment.

Result: Notice how the change analysis (Figure A2.18) reveals both planned and unplanned changes. Notice also how the worksheet brings all the changes into focus in context with each other. Any one of these changes are significant but not particularly unusual. When all of them are viewed in the context of the worksheet, the cumulative impact of all of the changes becomes apparent. The very probable cause of the “loose” flying is the optempo and resulting mental and physical stress on pilots. It is likely that a DO would intuitively be aware of many, if not all, of these factors. The role of the change analysis is to assemble the changes in a format where their cumulative impact is readily apparent. This situation is a good example where the impact of the individual changes is considerably greater than the sum of their individual impacts and only by considering all of the changes at one time can the real risk issue be understood.

Figure A2.18. Example of Change Analysis.

Target: <u>Unit flying operations</u> Date: _____				
FACTORS	EVALUATED SITUATION	COMPARABLE SITUATION	DIFFERENCE	SIGNIFICANCE
WHAT Objects Energy Defects Protective Devices				
WHERE On the object In the process Place				
WHEN In time In the process	25% plus up optempo	Baseline	Major plus up	Stress (mental & physical)
WHO Operator Fellow worker Supervisor Others	Avg crew flt hrs 30%reduction	Baseline	Major decrease	Significant exper level decrease
TASK Goal Procedure Quality	Estimate current flight profile 15% harder	Baseline	Significant task increase	Stress
WORKING CONDITIONS Environmental Overtime Schedule Delays	2 months bad weather Avg week now 62 hrs	Good weather Was under 50	Tougher flying Major increase	Stress Stress (mental & physical)
TRIGGER EVENT				
MANAGERIAL CONTROLS Control Chain Hazard Analysis Monitoring Risk Review	Current Cdr hard driver, demanding	Easygoing	More command pressure	Stress

A2.A.9. THE CAUSE AND EFFECT TOOL

A2.A.9.1. FORMAL NAME. The cause and effect tool

A2.A.9.2. ALTERNATIVE NAMES. The cause and effect diagram, The fishbone tool, the Ishikawa Diagram

A2.A.9.3. PURPOSE. The cause and effect tool is a variation of the logic tree tool and is used in the same hazard ID role as the general logic diagram (i.e. a more rigorous, detailed tool). The special advantage of the cause and effect tool is its origin in the quality management process and the thousands of personnel who have been trained in the tool. Because it is widely used, thousands of personnel are familiar with it and therefore require little or no training to apply it to the problem of detecting risk.

A2.A.9.4. APPLICATION. The cause and effect tool will be effective in organizations that have had some success with the quality initiative. As pointed out above, the tool is among the most commonly applied quality procedures and significant numbers of personnel are very comfortable using it. It should be used in the same manner as the logic diagram previously covered and can be applied in both a positive and negative variation.

A2.A.9.5. METHOD. The cause and effect diagram is essentially a logic diagram but with a significant variation. The cause and effect diagram provides more structure than the ordinary logic diagram through the branches that give it one of its alternate names, the fishbone diagram. Figure A2.19 illustrates this structure. Note that there are two basic variations, one for tactical type operations (the 4 “M”) and another for administrative processes (the 4 “P”). Of course the user can tailor the basic “bones” based on special characteristics of the operation or mission that is being analyzed. As in the case of the logic diagram, either a positive or negative outcome block is designated at the right side of the diagram. Then, using the structure of the diagram, the user or team of users completes the diagram by adding causal factors in either the “M” or “P” structure. By using branches off the basic entries, additional hazards can be added to the diagram. The examples provided illustrate this process. The cause and effect diagram is a very effective team hazard ID tool and should be used in a team setting whenever possible.

A2.A.9.6. RESOURCES. There are many publications describing in great detail how to use cause and effect diagrams.

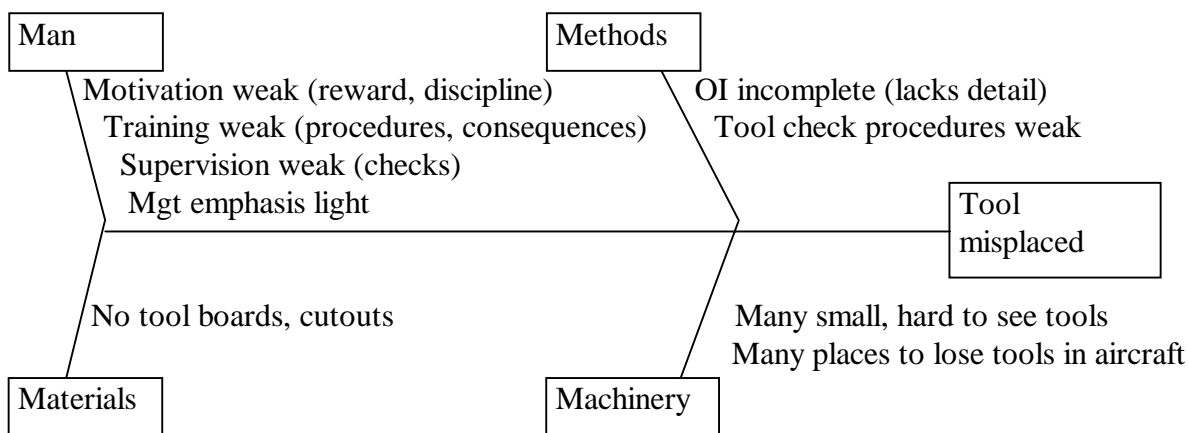
A2.A.9.7. COMMENTS. This procedure has proven very effective and has established the cause and effect diagram as a powerful hazard ID tool.

A2.A.9.8. EXAMPLES. An example of cause and effect tool in action is illustrated at Figure A2.19.

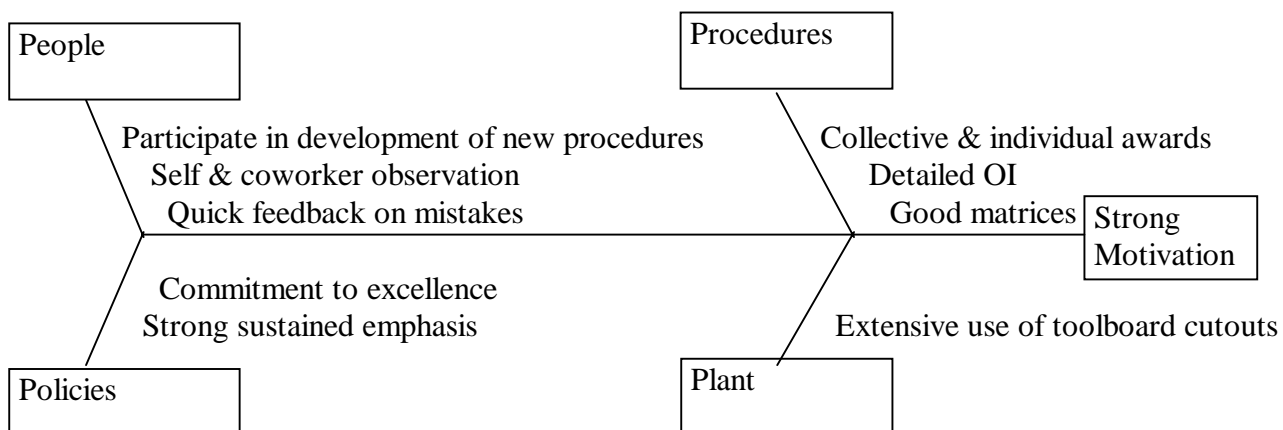
Figure A2.19. Example of Cause and Effect.

Situation: The supervisor of an aircraft maintenance operation has been receiving reports from Quality Assurance regarding tools in aircraft after maintenance over the last six months. The supervisor has followed up but each case has involved a different individual and his spot checks seem to indicate good compliance with tool control procedures. He decides to use a cause and effect diagram to consider all the possible sources of the tool control problem. The supervisor develops the cause and effect diagram with the help of two or three of his best maintenance personnel in a group application.

Note: Tool control is one of the areas where 99% performance is not adequate. That would mean 1 in a hundred tools is misplaced. The standard must be that in the tens (or hundreds) of thousands of individual uses of tools over a year literally not one is misplaced.



In reviewing the diagram detail the group agrees that in most of these areas the existing procedures are not bad. The problem is that not bad isn't good enough. Only excellence will do. They decide to use the "positive" variation of the cause and effect diagram. Their initial focus is on motivation.



Using the positive diagram as a guide the supervisor and his group proceed to apply all possible and practical options developed from the diagram above. The objective is to develop not just a good set of procedures but an **optimum** set of procedures.

SECTION A2.B. THE SPECIALTY HAZARD IDENTIFICATION TOOLS

A2.B.1. The fourteen tools that follow are specialty hazard identification tools designed to augment, as needed, the primary tools outlined in Section A2.A. These specialty tools fulfill several purposes as follows:

A2.B.1.1. They can be used by virtually all personnel of the organization but may require some training and safety professional facilitation.

A2.B.1.2. Each provides a special capability not fully realized in any of the primary tools.

A2.B.1.3. They use the tools of the traditional safety program to support the ORM process.

A2.B.1.4. They are generally well supported with forms, job aids, and models.

A2.B.1.5. Their effectiveness has been proven in field application.

A2.B.2. In an organization with a mature ORM culture, all personnel should be aware of the existence of these specialty tools and will be capable of recognizing the need for their application in support of the primary tools. While not every person will be comfortable using all of these procedures, a number of personnel within the organization will have experience applying them. Loss control professionals will be experienced in the role of assisting and facilitating in their application. The following pages describe each tool using a standard format, with models and examples.

A2.B.3. THE HAZARD AND OPERABILITY TOOL

A2.B.3.1. FORMAL NAME. The hazard and operability tool

A2.B.3.2. ALTERNATIVE NAMES. The HAZOP analysis

A2.B.3.3. PURPOSE. The special role of the HAZOP is hazard analysis of completely new operations. In these situations, traditional intuitive and experiential hazard ID procedures are especially weak. Because they are totally new, no one has any experience and there is little basis for intuition. This lack of experience hobbles tools such as the what if and scenario process tools which rely heavily on experienced operational personnel. The HAZOP deliberately maximizes structure and minimizes the need for experience to increase its usefulness in these novel situations.

A2.B.3.4. APPLICATION. As indicated above, the HAZOP should be considered when a completely new process or procedure is going to be undertaken. The issue should be one where there is significant risk because the HAZOP does demand significant expenditure of effort and may not be cost effective if used against low risk issues. The HAZOP is also useful when an operator or leader senses that “something is wrong” but they can’t identify it. The process of the HAZOP will dig very deep into the operation and is very likely to identify what the “something” is.

A2.B.3.5. METHOD. The HAZOP is certainly the most highly structured of the hazard ID procedures. It uses a standard set of guide terms (Figure A2.20) which are then linked in every possible way with a tailored set of process terms (for example “flow”). The process terms are developed directly from the actual process or from the operations analysis. The two words together, for example “no” (a guide word) and “flow” (a process term) will describe a deviation. These are then evaluated to see if a meaningful hazard is indicated. If so, the hazard is entered in the hazard inventory for further evaluation. Because of its rigid process, the HAZOP is especially suitable for one person hazard ID efforts.

Figure A2.20. Standard HAZOP Guidewords.

NO MORE LESS REVERSE EARLY LATE	Note: This basic set of guidewords should be all that are needed for all applications. Nevertheless, when useful, specialized terms can be added to the list. In less complex applications only some of the terms may be needed.
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A2.B.3.6. RESOURCES. Because of its rigid characteristics, there are few base-level resources available to assist with HAZOP; none are really needed.

A2.B.3.7. COMMENTS. The HAZOP is highly structured, one could say “rigid,” and often quite time-consuming. Nevertheless, in its special role, this tool works very effectively. It was selected by OSHA for inclusion in the set of six mandated procedures of the OSHA process safety standard.

A2.B.3.8. EXAMPLES. Extracts from a HAZOP application are illustrated in Figure A2.21.

Figure A2.21. Example HAZOP Application.

Situation: A ground support crew has been tasked to prepare to use new and unfamiliar equipment to load specialized munitions on the external hardpoints of an aircraft with which they have only limited experience. They decide to use a HAZOP to assess the hazards they may face in this situation. Because of the relative complexity of this operation, the complete HAZOP is quite extensive covering several worksheets. Extracted below is the worksheet for the MORE key word demonstrating its application in conjunction with the process parameters identified in this situation.

Key words: No, More, Less, Early, Late, Reverse

Process Terms: Position, raise, adjust, attach, remove safeties, check

CAUSES	CONSEQUENCES	SAFEGUARDS
<i>More Position</i>		
Take too long to properly position	Mission delay	Insure proficiency
<i>More Raise</i>		
Weapon pushed into aircraft	Damage to aircraft and/or weapon	Install stops, insure proficiency
<i>More Adjust</i>		
Take too long to attach weapon	Mission delay	Provide guides, Insure proficiency
<i>More Attach</i>		
Attachments overtorqued or stressed	Damage to weapon or aircraft Failure to release	Insure proficiency Insure right tools
<i>More Remove Safety</i>		
Safeties removed at wrong time or in wrong sequence	Damage to weapon or malfunction	Improve procedures Insure proficiency
<i>More Check</i>		
Take too long to check	Delay mission	Enhance procedures Insure proficiency

A2.B.4. THE MAPPING TOOL

A2.B.4.1. FORMAL NAME. The mapping tool

A2.B.4.2. ALTERNATIVE NAMES. Map analysis

A2.B.4.3. PURPOSE. The map analysis is designed to use terrain maps and other system models and schematics to identify both things at risk and sources of hazards. It is a powerful and convenient tool because military operations rely so heavily on maps and the tool can be easily tied to these military uses. Properly applied the tool will reveal the following:

- Mission elements at risk

- The sources of risk

- The extent of the risk (proximity)

- Potential barriers between hazard sources and mission assets

A2.B.4.4. APPLICATION. The mapping tool is an extremely versatile tool that can be used in a wide variety of situations. The explosive quantity-distance criteria is a classic example of map analysis. The location of the explosives is plotted and then the distance to various targets (inhabited buildings, highways, etc.) is determined. The same principles can be extended to almost any facility. We can use a diagram of a maintenance shop to note the location of hazards such as gases, pressure vessels, flammables, etc.. Key assets can also be plotted. Then potentially hazardous interactions are noted and the layout of the facility can be optimized in terms of risk reduction. Another obvious use is in the layout of billeting and bivouac areas from the point of view of both safety and force protection.

A2.B.4.5. METHOD. The mapping tool requires some creativity to realize its full potential. The starting point is a map, facility layout, or equipment schematic. The locations of potential hazard sources are noted. The easiest way to detect these sources is to locate energy sources. All hazards involve the unwanted release of energy. Figure A2.22 lists the basic kinds of energy to look for. Mark the locations of these sources on the map or diagram. Then, keeping the mission in mind, locate the personnel, equipment, and facilities that the various potentially hazardous energy sources could impact. Note these potentially hazardous links and enter them in the hazard inventory for risk management.

Figure A2.22. Major Types of Energy.

Electrical
Kinetic (moving mass e.g. a vehicle, a machine part, a bullet)
Potential (not moving mass e.g. a heavy object suspended overhead)
Chemical (e.g. explosives, corrosive materials)
Noise and Vibration
Thermal (heat)
Radiation (Nonionizing e.g. microwave, and ionizing e.g. nuclear radiation, x-rays)
Pressure (air, water)

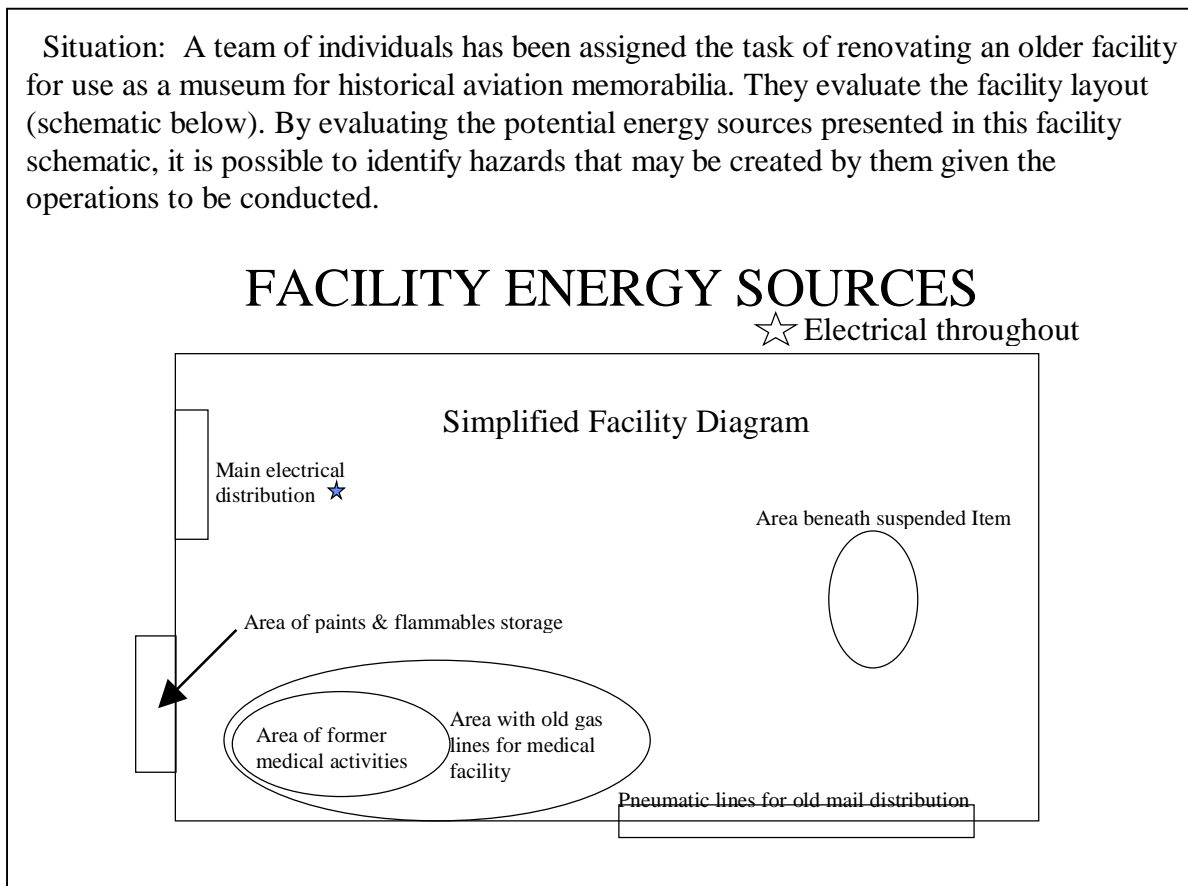
A2.B.4.6. RESOURCES. When working with terrain maps, someone who has actually seen the terrain in question is an invaluable asset. Maps can convey a great deal of information, but they can not replace the

value of an on-site assessment. Similarly, when working with an equipment schematic or a facility layout, there is no substitute for an on-site inspection of the equipment or survey of the facility.

A2.B.4.7. COMMENTS. The map analysis is valuable in itself, but it is also excellent input for many other tools such as the interface analysis, energy trace and barrier analysis, and change analysis.

A2.B.4.8. EXAMPLE. The following example (Figure A2.23) illustrates the use of a facility schematic that focuses on the energy sources there as might be accomplished in support of an energy trace and barrier analysis.

Figure A2.23. Example Map Analysis.



A2.B.5. THE INTERFACE ANALYSIS

A2.B.5.1. FORMAL NAME. The interface analysis

A2.B.5.2. ALTERNATIVE NAMES. None

A2.B.5.3. PURPOSE. The interface analysis is intended to uncover the potentially hazardous linkages or interfaces between otherwise unrelated activities. For example, we plan to build a new facility at a base. What hazards may be created for other operations on the base during construction and after the facility is opened? The interface analysis is designed to reveal these potential hazards by focusing on energy exchanges. A hazard necessarily involves the transfer of energy from one point to another. By looking at these potential energy transfers between two different activities we can often detect important hazards that are difficult to detect in any other way.

A2.B.5.4. APPLICATION. Generally speaking an interface analysis should be conducted any time a new activity is being introduced and there is any chance at all that unfavorable interaction could occur. A good cue to the need for an interface analysis is the use of either the change analysis (indicating the injection of something new) or the map analysis (with the possibility of interactions).

A2.B.5.5. METHOD. The interface analysis is normally based on an outline such as the one illustrated at Figure A2.24. Interfaces take the form of energy exchanges, so the outline provides a list of potential energy types and guides consideration of the potential interactions. A determination is made whether a particular type of energy is present and then whether there is potential for that form of energy to adversely impact on other activities. As in virtually all aspects of hazard ID, the creation of a good operations analysis assures that interactions in all phases of the lifecycle are considered.

Figure A2.24. The Interface Analysis Worksheet.

Energy Element

- Kinetic (objects in motion)
- Electromagnetic (microwave, radio, laser)
- Radiation (radioactive, x-ray)
- Chemical
- Other

Personnel Element: Personnel moving from one area to another

Equipment Element: Machines and material moving from one area to another

Supply/materiel Element:

- Intentional movement from one area to another
- Accidental movement from one area to another

Product Element: Movement of product from one area to another

Information Element: Flow of information from one area to another or interference (i.e. jamming)

Bio-material Element

- Infectious materials (virus, bacteria, etc.)
- Wildlife
- Odors

A2.B.5.6. **RESOURCES.** Interface analyses are best accomplished when personnel from all of the involved activities participate in the process. In this way hazards and interfaces in *both* directions can be effectively and knowledgeably addressed. A safety office representative can also be useful in advising on the types and characteristics of energy transfers that are possible.

A2.B.5.7. **COMMENTS.** The lessons of the past indicate that we should give serious attention to use of the interface analysis. Virtually anyone who has been involved in military operations for any length of time can relate stories of overlooked interfaces that have had serious adverse mission consequences.

A2.B.5.8. **EXAMPLES.** An interface analysis using the general outline is shown below.

Figure A2.25. Example Interface Analysis.

Situation: Construction of a major heavy equipment maintenance facility is planned for the periphery of the main base complex at a major air base. This is a major complex costing over \$20,000,000 and requiring about eight months to complete. The objective is to detect interface issues in both directions. Notice that the analysis reveals a variety of interface issues that need to be thought through carefully.	
<i>Energy Interface</i>	Movement of heavy construction equipment Movement of heavy building supplies Movement of heavy equipment for repair Possible hazmat storage/use at the facility
<i>Personnel Interface</i>	Movement of construction personnel (vehicle or pedestrian) through base area Movement of repair facility personnel through base area Possible movement of base personnel (vehicular or pedestrian) near or through the facility
<i>Equipment Interface:</i> Movement of equipment as indicated above	
<i>Supply Interface</i>	Possible movement of hazmat through base area Possible movement of fuels and gases Supply flow for maintenance area through base area
<i>Product Interface</i>	Movement of equipment for repair by tow truck or heavy equipment transport through the base area
<i>Information Interface</i>	Damage to buried or overhead wires during construction or movement of equipment Possible electro-magnetic interference due to maintenance testing, arcing, etc.
<i>Bio-material Interface:</i> None	

A2.B.6. THE MISSION PROTECTION TOOL

A2.B.6.1. FORMAL NAME. The mission protection tool

A2.B.6.2. ALTERNATIVE NAMES. None

A2.B.6.3. PURPOSE. The mission protection tool is designed to focus explicitly on protection of the mission rather than on protection of personnel or things. The tool recognizes the fact that the mission can be stopped partially or completely by events that may injure no one and cause very little damage. Since there is little injury or damage risk, these hazards could easily be categorized as low risk under traditional criteria. The mission protection tool ignores injury or damage issues and instead concentrates on the mission. What are the key components of mission continuity and success and what could interrupt them? A special characteristic of the mission protection analysis is its consideration of **any** source of mission interruption, not just those arising from traditional mishap sources. For example, a mission protection analysis is as concerned about the interruption of mission critical spare parts due to a transportation strike as it would be as a result of an interruption caused by a vehicle mishap.

A2.B.6.4. APPLICATION. As time and resources permit, mission protection analyses should be completed on all the major missions of an organization. The most important missions should be analyzed first with other missions following in the appropriate order.

A2.B.6.5. METHOD. The mission protection analysis has no particular method. This tool is characterized by its focus rather than its method. When the decision is made to complete a mission protection application, the responsible person examines the nature of the mission and then chooses from the full range of available hazard ID tools those that will prove most effective. The most likely tools to be used are the primary hazard ID tools, but many of the specialty hazard ID tools will also be useful. Mission protection analyses can be extended to any level of detail, but for important missions, the in-depth analysis is appropriate.

A2.B.6.6. RESOURCES. A clear and detailed statement of the mission is an important resource for the mission protection tool. Also, diagrams of the key processes used to accomplish the mission are important. Because this tool lacks any fixed process and there are no job aids. A representative of the safety office will be an important asset who will be particularly useful in selecting the best combination of hazard ID tools to use.

A2.B.6.7. COMMENTS. The idea of **mission** is at the heart of the risk management process. What is risk management all about? Optimizing the mission! The mission protection tool is central to fully effective ORM.

A2.B.6.8. EXAMPLES. An example of the process that might be used to select a set of tools for the mission protection analysis of a mission critical computer facility is illustrated in Figure A2.26.

Figure A2.26. Example Mission Protection Application.

Situation: A major material management center uses a computer to help management the complex distribution and cost accounting needed to successfully carry out the mission. If this computer were to be seriously impaired in any way, the mission could be down for a time ranging from several hours to several days. The decision is made to complete an in-depth mission protection analysis of the computer operation. The individual responsible for the applications uses his hazard ID toolbox to select the following tool for this important mission protection analysis.

TOOLS TO BE USED

Operations analysis (to establish the full dimension of the operation)
What if analysis (to establish contingency-type threats to the mission)
Interview tool (to get inputs from personnel involved in the operation)
Several Logic Diagrams (used to explore several of the higher risk issues revealed by the tools above.)
Interface tool (used to detect any threats from non-related functions)
Change analysis tool (to assess any intentional or unintentional change in the last 1 or 2 years.

The products derived from this analysis is essentially the same as the hazard identification assessments except that the focus is on those things, whether they cause physical damage or injury or not, that impact the mission of the system.

A2.B.7. THE SAFETY QUIZ

A2.B.7.1. FORMAL NAME. The safety knowledge assessment

A2.B.7.2. ALTERNATIVE NAMES. The safety quiz

A2.B.7.3. PURPOSE. Human error is a key cause factor in mishaps and the creation of risk. One of the key sources of human error is lack of knowledge of hazards and risk control procedures. The safety quiz is designed to measure the degree to which critical hazard and risk control knowledge is possessed by a given target group. Another aspect of the safety quiz tool is the attitude survey. The objective is to assess attitudes toward risk control processes and requirements.

A2.B.7.4. APPLICATION. The safety quiz should be used to assess the status of risk related knowledge and attitudes that are connected to high and extremely high risks issues. It should also be used when other hazard ID tools seem to indicate a skill, knowledge, or attitudinal problem. Alternatively this tool can be used to assess progress in continuously improving these key areas. In these situations, the quiz is used to assess the degree of the problem and pinpoint the specific areas of weakness.

A2.B.7.5. METHOD. The key to the safety quiz is the selection and development of the questions that are placed on the quiz. It is essential that these questions be solidly linked to real hazards. Do the questions really determine that the target group has the necessary skills and knowledge or attitudes to perform safely? Note that the group may not be performing safely even though it has the needed knowledge. In these cases, the problem is motivation, not skills or knowledge. A second important consideration is the administrative process of administering and using the quiz. Quizzes should be timed to minimize the administrative burden on the organization. Safety standdown days are an excellent opportunity to use quizzes. Also care should be taken to avoid unnecessarily embarrassing individuals who may score poorly. There may be many reasons for poor performance and it is important not to turn the quiz process into a negative event. The quiz should be only as long as necessary to evaluate key knowledge and attitudes.

A2.B.7.6. RESOURCES. An experienced trainer can be of real help in insuring that questions are well developed. An effective database or risk information management system (RIMS) is also important in selecting the critical skills and knowledge to be evaluated.

A2.B.7.7. COMMENTS. The safety quiz is an efficient and effective way to ensure that the organization possesses the risk control skills, knowledge and attitudes needed to achieve ORM success.

A2.B.7.8. EXAMPLES. Extracts from safety quizzes targeted at skills and knowledge are provided at Figure A2.27.

Figure A2.27. Example Safety Quiz Applications.

Situation: The supervisor of a maintenance facility in which considerable quantities of hazmat are used is concerned about the extent of knowledge his personnel have of some critical emergency procedures that must be followed in the event of a variety of possible failure modes. He develops an eight question quiz that samples key knowledge from the required procedures. The best questions are those that are tailored to the situation.

Questions extracted from such a quiz are listed below.

3. List the four required steps in the event of a reading of over 350 lbs. on the primary pressure gauge.

- a. _____
- b. _____
- c. _____
- d. _____

5. Who must be notified in the event of a type 3 incident and how do you contact them?

Name_____ Method of Contact_____

7. The four steps for operating the dry chemical fire extinguishers used in this facility are:

- Step 1 _____
- Step 2 _____
- Step 3 _____
- Step 4 _____

Notice how vital the information obtained from these quizzes can be in understanding exactly how well the risk control program is progressing.

A2.B.8. THE NEXT MISHAP ASSESSMENT

A2.B.8.1. FORMAL NAME. The next mishap assessment

A2.B.8.2. ALTERNATIVE NAMES. None

A2.B.8.3. PURPOSE. Research has established that there are certain indicators that show a statistically significant correlation with high risk of mishap involvement. The next mishap assessment uses this information to assess the likelihood that a given activity or situation will result in a mishap. The ability to pinpoint risks opens the door to resolution with focused effort.

A2.B.8.4. APPLICATION. The next mishap assessment is an excellent safety standdown day or safety meeting agenda item. Variations of the next mishap assessment tools exist to support individual self assessment or for leaders to assess inputs from their subordinates. Because an organization's risk changes over time as mission circumstances change, it is useful to repeat the assessment process once every year or two.

A2.B.8.5. METHOD. There are a variety of next mishap assessment tools. These tools should be used and locally developed tools should be avoided. Assessments should not be developed locally because the research necessary to validate the product can not normally be accomplished by anyone other than specialized professionals. These include:

A2.B.8.5.1. Self assessment tools that are used by individuals and only the user knows the outcome.

A2.B.8.5.2. Leader tools used to assess risk proneness of subordinates.

A2.B.8.5.3. Tools specialized to the aviation arena.

A2.B.8.6. RESOURCES. There are a variety of established next mishap assessment tools. Guidance on locating these tools can be obtained from the Air Force Safety Center or your local safety office. Other copyrighted tools are available commercially. Your local safety office can direct you to these items.

A2.B.8.7. COMMENTS. Next mishap assessments are effective tools that allow focus specifically where the problems are, not on everything. That is the essence of the risk management process.

A2.B.8.8. EXAMPLES. Examples of these tools can be obtained from the sources outlined above.

A2.B.9. THE MISSION MISHAP ANALYSIS

A2.B.9.1. FORMAL NAME. The mission mishap analysis

A2.B.9.2. ALTERNATIVE NAMES. The mission accident analysis

A2.B.9.3. PURPOSE. Most organizations have accumulated extensive, detailed mishap databases that are gold mines of risk data. The purpose of the mission mishap analysis is to assure that this data is being effectively applied to the prevention of future mishaps.

A2.B.9.4. APPLICATION. Every organization should complete a mission mishap analysis annually. The objective is to update the understanding of current mishap trends and causal factors. Changes that occur in less than a year are not likely to be statistically significant. Waiting more than a year may miss important changes in trends. The analysis should be completed for each organizational component that is likely to have unique mishap factors.

A2.B.9.5. METHOD. The art and science of mishap analysis can be approached in many ways. Essentially it relies on Pareto's law (the fact that in a wide variety of activities, 80% of the problems are found in 20% of the exposure). For example, 80% of the unsafe acts in a group of employees may be committed by only 20% of the employees. The process of mission mishap analysis is finding the 20% of personnel, facilities, activities, etc. that are causing the bulk of the risk in the organization. If the mishap database is computerized, the computer can do much of the initial sorting of the data. A human analyst will have to do the final interpretation of the data. If the work must be done manually, the process involves the determination of likely risk factors and then the examination of the data to determine if the factors in fact exist. Typical factors to examine include the following:

A2.B.9.5.1. Activity at the time of the mishap.

A2.B.9.5.2. Distribution of mishaps among personnel.

A2.B.9.5.3. Mishap locations.

A2.B.9.5.4. Distribution of mishaps by sub-unit.

A2.B.9.5.5. Patterns of unsafe acts or conditions.

A2.B.9.6. RESOURCES. The mission mishap analysis relies on a relatively complete and accurate mishap database. The base safety office will normally have the needed data. That office can also provide assistance in the analysis process. Safety personnel may have already completed analyses of similar activities or they may be able to suggest the most productive areas for initial analysis.

A2.B.9.7. COMMENTS. The data in mishap databases has been acquired the hard way - through the painful and costly mistakes of hundreds of individuals. It is tragic when organizations fail to take full advantage of this information and therefore doom themselves to experience the same failures over and over again.

A2.B.9.8. EXAMPLES. Examples of mishap analyses and mishap data available can be obtained from servicing safety offices.

A2.B.10. THE INTERVIEW TOOL

A2.B.10.1. FORMAL NAME. The interview tool

A2.B.10.2. ALTERNATIVE NAMES. None

A2.B.10.3. PURPOSE. Some of the most knowledgeable personnel in the area of risk are the personnel who are operating the system. They are there every working hour of every working day, seeing the problems and hopefully occasionally think about potential solutions. The purpose of the interview tool is to capture the risk related experience of these personnel in ways that are efficient and positive for the people involved. Properly implemented, the interview tool can be among the most valuable hazard ID tools.

A2.B.10.4. APPLICATION. Because of its versatility, there is no reason that every organization can't use the interview tool in one form or another.

A2.B.10.5. METHOD. The interview tool's great strength is versatility. Figure A2.28 illustrates the many options available to collect interview data. A key to all of these is to create a situation in which personnel feel free to honestly report what they know without fear of any retribution or adverse consequences. This means absolute confidentiality. This may be guaranteed by not using names in connection with data.

Figure A2.28. Interview Tool Alternatives.

1. Direct interviews with operational personnel.
2. Supervisors interview their subordinates and report results.
3. Questionnaire interviews are completed and returns (see the exit interview above).
4. Group interview sessions (several personnel at one time).
5. Hazards reported formally or informally.
6. Coworkers interview each other.

A2.B.10.6. RESOURCES. It is possible to operate the interview process on a base-wide basis with the data being supplied to individual units. Safety offices often operate such systems. Interview processes can also be integrated in other interview activities. For example, leader-subordinate counseling sessions can be modified to include a hazard interview segment. In these ways, the expertise and resource demands of the interview tool can be minimized.

A2.B.10.7. COMMENTS. The heart of the mishap problem and the key source of risk is human errors. Of all the hazard ID tools, the interview tool is potentially the most effective at capturing human error data. By choosing from among the many variations of the tool, it can also be among the most efficient.

A2.B.10.8. EXAMPLES. Figure A2.28 illustrates several variations of the interview tool. One or more of these can be effective in your organization. For example, the exit interview tool asks individuals leaving the command to report hazards on a short form (Figure A2.29) completed during the outprocessing cycle.

Because they are outprocessing, there is no loss of productivity and personnel tend to be more open and candid in their comments.

Figure A2.29. Example Exit Interview Format.

Name (optional)_____ Organization _____	
<p>A major interest of any commander is finding out what is not really going as well as it should in his/her command. One important responsibility is seeing that working conditions for his people are as safe and healthy as possible. Last year over 100 Air Force personnel died in mishaps. Your help is needed in eliminating the causes of these losses. You can help significantly by answering carefully and thoroughly the questions below. Thanks for your cooperation in making this unit a safer and better place to live and work.</p>	
<p>1. Describe below at least two mishaps, near misses or close calls that you have experienced or seen since you have been in this organization. State the location and nature (i.e. what happened and why) of the incident. If you can't think of an incident, then describe two hazards you have observed.</p>	
<p>INCIDENT 1, Location.</p> <p>What happened and why?</p>	
<p>INCIDENT 2, Location</p> <p>What happened and why?</p>	
<p>2. What do you think other personnel, supervisors, and top leadership can do to eliminate these problems:</p>	
Personnel:	Incident 1
	Incident 2
Supervisors:	Incident 1
	Incident 2
Top Leadership:	Incident 1
	Incident 2

A2.B.11. THE INSPECTION TOOL

A2.B.11.1. FORMAL NAME. The inspection tool

A2.B.11.2. ALTERNATIVE NAMES. The survey tool

A2.B.11.3. PURPOSE. Inspections have two primary purposes. The first is the detection of hazards. Inspections accomplish this through the direct observation of operations. The process is aided by the existence of detailed standards against which operations can be compared. The OSHA standards and various national standards organizations provide good examples. The other purpose is to evaluate the degree of compliance with established risk controls. Non-compliance with established risk controls is hazardous, so in a sense both purposes are the same thing. When inspections are targeted at management and safety management processes they are usually called surveys. These surveys assess the effectiveness of management procedures by evaluating status against some survey criteria or standard. In addition to the two major objective outlined above, inspections are also important as accountability tools and can even be turned into important training opportunities.

A2.B.11.4. APPLICATION. Inspections and surveys are used in the risk management process in much the same manner as in traditional safety programs. However, in the ORM concept these tools are much more focused on critical risk factors. Where the traditional approach may require that all facilities be inspected on the same frequency schedule, the ORM concept would dictate that high risk activities may be inspected ten times or more frequently than lower risk operations, and that some of the lowest risk operations might only be inspected once every five years or so. The degree of risk drives the frequency and depth of the inspections and surveys.

A2.B.11.5. METHOD. There are as many methods of conducting inspections as there are safety offices. From a risk management point of view the key is focus. What will be inspected? The risk management response is the highest risks. The first and most important step in effective inspections is the selection of inspection criteria and the development of the inspection checklist or protocol. This must be a risk-based process. Commercial protocols are available that contain criteria validated to be connected with safety excellence. Alternatively, excellent criteria can be developed using mishap databases and the results of other hazard ID tools such as the operations analysis and logic diagrams, etc.. Many excellent inspection and survey processes have been developed within the Air Force. Some these have been computerized to facilitate entry and processing of data. Once solid criteria are developed, a schedule is created and inspections are begun. It is important that the conduct of inspection be as positive an experience as possible. Personnel performing inspections should be carefully trained, not only in the technical processes involved, but also in the human relations aspects. During inspections, the ORM concept encourages another departure from traditional inspection practices. Instead of noting deficient performance as in traditional procedures, the ORM concept also encourages recording of observation that meet or exceed the standard. This practice makes it possible to evaluate the trend in organization performance by calculating the percentage of unsafe (non-standard) versus safe (meet or exceed standard) observations. Once the observations are made the data must be carefully entered in the overall hazard inventory database. Once in the database the data can be analyzed as part of the overall body of data or as a mini-database composed of inspection findings only.

A2.B.11.6. **RESOURCES.** As noted above there are many inspection criteria, checklists and related job aids available commercially and within the Air Force. Many of these have been tailored for specific types of organizations and activities. The local safety office can be a valuable resource in the development of inspection and survey criteria and can provide technical support in the form of interpretations, procedural guidance, and correlation of inspection data with other like units.

A2.B.11.7. **COMMENTS.** Inspections and surveys have long track records of success in detecting hazards and reducing risk. They have been criticized as being inconsistent with modern management practice because they are a form of “downstream” quality control. By the time a hazard is detected, it already exists and may have already have caused loss. The ORM approach to inspections emphasizes focus on the higher risks within the organization and emphasizes the use of management and safety program surveys that detect the underlying root causes of hazards rather than the hazards themselves. Properly designed and conducted, inspections and surveys retain a vital place in an effective risk management process.

A2.B.11.8. **EXAMPLES.** Conventional inspections normally involve seeking and recording unsafe acts/conditions. The number of unsafe acts/conditions can be the result of either the number of unsafe acts/conditions in the organization or possibly the extent of effort extended to find hazards. Conventional inspections can never be a reliable indicator of the extent of risk. To change the nature of the process to reliably indicate the extent of risk, it is often only necessary to record the total number of observations made of key behaviors and then determine the number of unsafe behaviors. This yields a rate of “unsafeness” that is independent of the number of observations made.

A2.B.12. THE MISHAP/INCIDENT INVESTIGATION

A2.B.12.1. FORMAL NAME. The mishap/incident investigation

A2.B.12.2. ALTERNATIVE NAMES. The incident tool

A2.B.12.3. PURPOSE. The traditional mishap investigation has the objective of determining the causes of a mishap so that these causes can be eliminated or mitigated. The ORM approach adds a new dimension to the traditional concept. ORM stresses the determination of the inadequacies in the risk management process that allowed the mishap cause factors to impact the organization. A mishap investigation therefore becomes primarily an investigation of the risk management process itself to determine if it can be strengthened to control the risk factors that led to the mishap. The question now is not only what is the cause, but also how could the cause exist in the context of the risk management process.

A2.B.12.4. APPLICATION. Ideally all mishaps and incidents should be thoroughly investigated. Unfortunately, mishap investigations are expensive. Ideally the organization should have a process to select mishaps and incidents against which to allocate limited investigative resources. Severity is a relevant factor in this decision, but it should not be the dominate factor that it is in most investigation systems today. Simply because a mishap was serious does not mean that it is worth in-depth investigation. On the other hand, what appears on the surface to be a minor incident may be a gold mine of data regarding the risk management process. An effective risk manager will be able to sort out the opportunities and direct the investigative effort where it will produce the best return on investment.

A2.B.12.5. METHOD. Both the technical and management processes involved in a mishap/incident investigation are complex beyond the scope of this publication. Detailed guidance is provided in Air Force publications. From a risk management perspective the key is to investigate the risk management issues that are the cause of the direct mishap causes. Only by correcting these root risk management cause factors will the mishap investigation process be fully effective.

A2.B.12.6. RESOURCES. Most safety offices have personnel trained in detail in mishap investigation processes. They can serve as consultants in this critical process. Policy and procedures to follow in the process of investigating and reporting mishaps is contained in AFI 91-204, Safety Investigations and Reports, and applicable supplements.

A2.B.12.7. COMMENTS. Mishap and incident investigations have a long track record of success in preventing future mishaps.

A2.B.12.8. EXAMPLES. Base safety offices can provide guidance on the investigation and reporting process and on the use of the data for hazard identification.

A2.B.13. THE JOB HAZARD ANALYSIS

A2.B.13.1. FORMAL NAME. The job hazard analysis

A2.B.13.2. ALTERNATIVE NAMES. The task analysis, job safety analysis, JHA, JSA

A2.B.13.3. PURPOSE. The purpose of the job hazard analysis (JHA) is to examine in detail the safety considerations of a single job. A variation of the JHA called the task analysis focuses on a single task. The idea is to get into the job or task in detail and maximize the effectiveness of the safety procedures.

A2.B.13.4. APPLICATION. Some organizations have established the goal of completing JHAs on every job in the organization. If this can be accomplished cost effectively, it is a worthwhile goal. Certainly, the higher risk jobs in an organization warrant application of the JHA procedure. Within the risk management approach, it is important that such a plan be accomplished by beginning with the most significant risk areas first.

A2.B.13.5. METHOD. The JHA is best accomplished using an outline similar to the one illustrated at Figure A2.30. As shown on the illustration, the job is broken down into the individual job steps. Jobs that involve many quite different tasks should probably be handled by analyzing each major task on a separate form. Notice that the illustration considers both risks to the workers involved and to the system. It also considers risk controls for both risk issues. Tools such as the scenario and what if tools can contribute to the identification of potential worker or system hazards. There are two basic strategies for accomplishing the JHA process. The first involves a safety professional completing the process by asking questions of the workers and supervisors involved. The second involves providing supervisors training in the JHA process and motivating them to analyze the jobs they supervise. Either approach will work, the key is to involve the personnel actually doing the job.

Figure A2.30 Sample Job Hazard Analysis Format.

Job Safety Analysis	Job Title or Operation		Page ___ of ___ JSA Number
	Job Series/AFSC		Supervisor
Organization Symbol	Location/Building Number	Shop Title	Reviewed By
Required and/or Recommended Personal Protective Equipment			Approved By
SEQUENCE OF BASIC JOB STEPS	POTENTIAL HAZARDS UNSAFE ACTS OR CONDITIONS	RECOMMENDED ACTION OR PROCEDURE	

A2.B.13.6. **RESOURCES.** Most safety offices have personnel trained in detail in the JHA process. They can serve as consultants and may even have videos that walk a person through the entire process.

A2.B.13.7. **COMMENTS.** The JHA is risk management at its best. The concept of completing in-depth hazard assessments of all jobs involving significant risk with the active participation of the personnel doing the work is an ideal model of ORM in action.

A2.B.13.8. **EXAMPLES.** Examples can be obtained from Safety Offices on many different types of operations.

A2.B.14. THE BEHAVIOR OBSERVATION TOOL

A2.B.14.1. FORMAL NAME. The behavior observation tool

A2.B.14.2. ALTERNATIVE NAMES. The performance management tool

A2.B.14.3. PURPOSE. The behavior observation tool (BOT) is a specialized inspection tool designed to improve performance in risk critical behavioral areas and create a high degree of positive employee involvement. It uses modern performance management technology to create performance improvements in risk critical areas.

A2.B.14.4. APPLICATION. The BOT is a sophisticated tool that requires the commitment of the total organization. If an adequate foundation is in place, the BOT can improve safety performance by 50% or more. Because of the resource demands of the process, it should only be undertaken in situations in which risk reductions will produce important mission benefits.

A2.B.14.5. METHOD. The BOT process consists of several steps. The first is the commitment of management to the process. This commitment is ideally undertaken with full consultation with operating personnel of the organization and with union leaders if civilian employees are involved. The second step is to identify critical behaviors. These are behaviors that have a clear and direct connection to risk and associated losses in the organization. Selection of critical behaviors should involve the full participation of operators. These critical behaviors are carefully analyzed and the criteria for safe versus unsafe performance are clearly stated. On this foundation, a group of employees from the various organizational elements participating in the application are selected and trained in the BOT inspection process. This training involves clearly understanding the safe behavior criteria and, more importantly, the procedures for making observations of fellow employees. The trained observers make workplace observations of their fellow employees on a regular schedule. The observations are performed in an open and non-threatening manner with the full knowledge of the employee(s) being observed. The observer provides immediate feedback to the employees stressing things done correctly, but noting unsafe performance as well. This feedback is entirely without accountability and is fully confidential. The observer then provides feedback to a program coordinator regarding the percent safe versus unsafe for each of the critical behaviors. This data is not linked to any particular observations to protect the confidentiality of all involved. The program coordinator then rolls the data up into a total for each critical behavior. This information is provided to the total workforce on a regular schedule, at least monthly. This is often accomplished using a large graph posted right in the workplace. As certain major “safe” behavior milestones are reached, the work group may claim certain rewards.

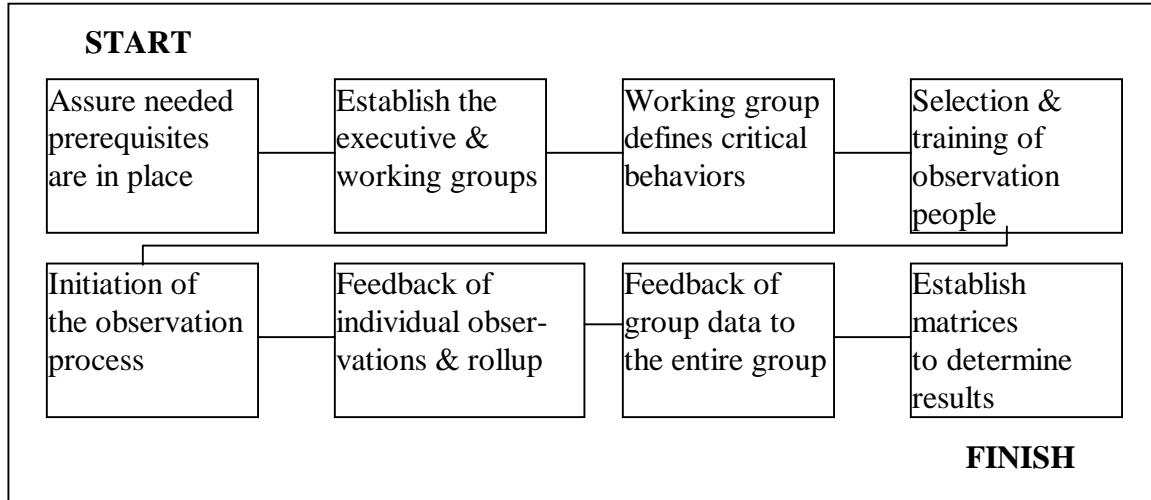
A2.B.14.6. RESOURCES. There are many safety offices that have personnel trained in the BOT process. Several DoD locations have experience in the implementation of the behavior observation tool. The Air Force Safety Center can provide information about these sites.

A2.B.14.7. COMMENTS. The BOT is a powerful, high operator involvement tool that can dramatically reduce unsafe behavior and ultimately mishaps. Successful application requires sophisticated understanding of the tool and the willingness to invest considerable resources up-front in the form of

training and observation time. Success also depends on the organization using it possessing certain characteristics that form a foundation for BOT application.

A2.B.14.8. EXAMPLES. A flow diagram illustrating the BOT implementation process is illustrated at Figure A2.31.

Figure A2.31. Flow Diagram For the Behavior Observation Tool.



A2.B.15. THE TRAINING REALISM ASSESSMENT

A2.B.15.1. FORMAL NAME. The training realism assessment

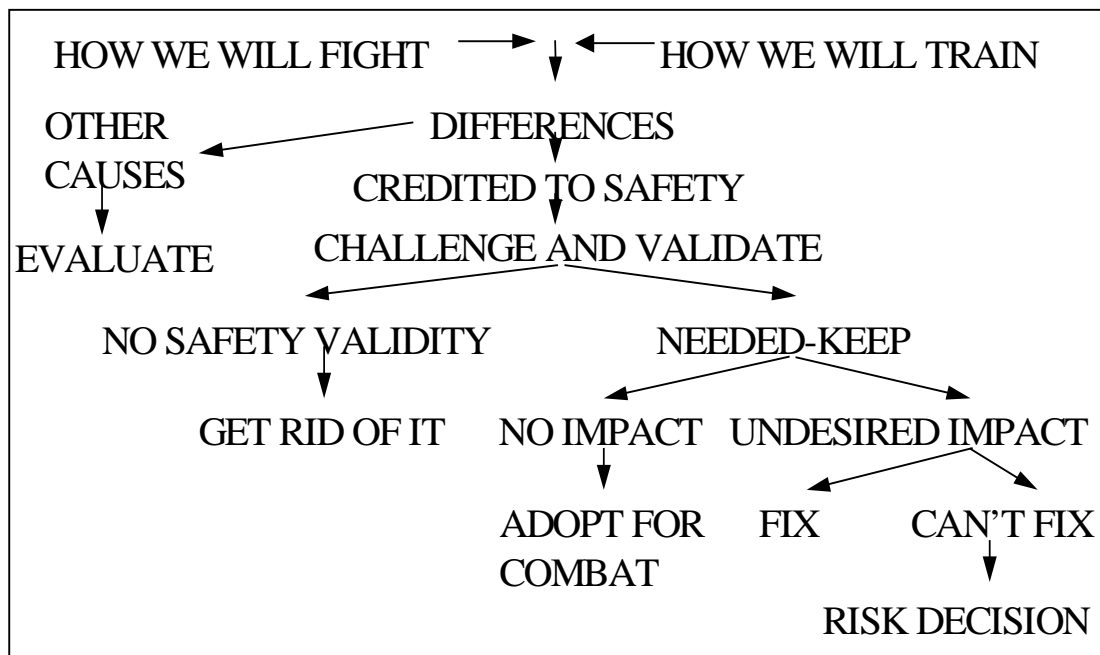
A2.B.15.2. ALTERNATIVE NAMES. None

A2.B.15.3. PURPOSE. The training realism assessment (TRA) is a procedure intended to assist in the detection and elimination or modification of safety restrictions that prevent fully effective training of military missions. Using a logic tree, the TRA assists in the detection of training realism shortcomings and then guides the user through the alternatives for overcoming them.

A2.B.15.4. APPLICATION. The TRA is among the most critical ORM procedures in military organizations. The TRA should be applied in every case where there are significant differences between how the organization trains and how it intends to fight. It can also be used periodically to detect such differences.

A2.B.15.5. METHOD. The TRA uses a job aid such as the one shown at Figure A2.32. The user identifies either a training application or a combat procedure. The training procedure is then compared step by step with the combat procedure (or vice versa). When differences are detected they are evaluated using the procedures in the job aid.

Figure A2.32 Sample TRA Job Aid.



A2.B.15.6. RESOURCES. Effective use of the TRA depends on the availability of personnel who understand in detail both the training and combat procedures.

A2.B.15.7. COMMENTS. In a military organization, the TRA is a primary ORM tool that can not be overlooked. ORM seeks to create the optimum level of risk, not the lowest level of risk. The TRA is a key tool in achieving the optimum goal. Omitting use of the TRA creates the real risk that the ORM process may result in inappropriately conservative risk decisionmaking in pursuit of reduced risk as an end in itself. However, do not forget that ORM does not authorize violation of policy or standards. If an assessment identifies an area where a policy or standard unnecessarily restricts operations, seek to have the item changed or request a waiver as appropriate through applicable channels.

A2.B.15.8. EXAMPLES. An example of the TRA in action is provided at Figure A2.33. Note that training realism assessments almost invariable create controversy. The objective of the tool is to resolve this controversy on the basis of the best possible information and on the foundation of the best possible risk management principles. The outcome should be a course of action in the best interests of the overall Air Force and national interests.

Figure A2.33. Example TRA.

Mission: Ground attack

Operational procedure: Release ordnance at 300 feet AGL.

Training procedure: Release ordnance at 500 feet AGL

Difference due the perceived risk of releasing at 300 feet

Safety validity of the difference: This difference does significantly reduce risk in the training environment. The difference can not be readily dismissed.

This difference does have a significant adverse operational impact in that pilots consistently attacking at 500 feet are not fully proficient in conducting attacks at 300 feet. Additionally they may lack full confidence in their ability to attack at that level. Also attacking at 500 feet significantly reduces the accuracy of attacks and therefore reduces the accuracy of the potential combat effectiveness of units. The 500 foot level can not be adopted for combat operations.

Potential options (fixes) for reducing the adverse impact of training for such attacks at 500 feet:

1. Fully investigate the potential of technology to improve accuracy at 500 feet to that achievable at 300 feet. Any such solution must be consistent with resources readily available for procurement of this technology.
2. Determine (the best possible estimate) the amount of exposure to the 300 foot level needed to assure essential proficiency in attacking at 300 feet.
3. Quantitatively assess the actual incremental risk of attacking at 300 feet versus 500 feet in the training environment.
4. Determine in detail the specific hazards (e.g. rising terrain, etc.) that create the increased risk of flying at 300 versus 500 feet.
5. Develop the best possible estimates of the increased risk of flying at 300 feet in combat and the extent to which ground strike accuracy is decremented if all training has been at 500 feet.
6. Based on the data above, make the judgments as to what, if any, training at 300 feet may be appropriate in the training environment and under what flight profiles it should most effectively be accomplished. An accurate accounting of both the positive and negative components of the options may be condensed for presentation and decision by the appropriate leader.

A2.B.16. THE OPPORTUNITY ASSESSMENT

A2.B.16.1. FORMAL NAME. The opportunity assessment

A2.B.16.2. ALTERNATIVE NAMES. The opportunity-risk tool

A2.B.16.3. PURPOSE. The opportunity assessment is intended to identify opportunities to expand the capabilities of the organization and/or to significantly reduce the operational cost of risk control procedures. Either of these possibilities means expanded mission capabilities and superiority over potential future adversaries.

A2.B.16.4. APPLICATION. Organizations should be systematically assessing their capabilities on a regular basis, especially in mission critical areas. The opportunity assessment can be one of the most useful tools in this process and therefore should be completed on all important missions and then be periodically updated at least every two years.

A2.B.16.5. METHOD. The opportunity assessment involves five key steps as outlined at Figure A2.34. In Step 1, mission areas that would benefit substantially from expanded capabilities are identified and prioritized. Additionally, areas where risk controls are consuming extensive resources or are otherwise constraining mission capabilities are listed and prioritized. Step 2 involves the analysis of the specific risk-related barriers that are limiting the desired expanded performance or causing the significant expense. This is a critical step. Only by identifying the risk issues precisely can focused effort be brought to bear to overcome them. Step 3 attacks the barriers by using the risk management process. This normally involves reassessment of the hazards, application of improved risk controls, improved implementation of existing controls, or a combination of these options. Step 4 is used when available risk management procedures don't appear to offer any breakthrough possibilities. In these cases the organization must seek out new ORM tools using benchmarking procedures or, if necessary, innovate new procedures. Step 5 involves the exploitation of any breakthroughs achieved by pushing the operational limits or cost saving until a new barrier is reached. The cycle then repeats and a process of continuous improvement begins.

Figure A2.34. Opportunity Analysis Steps.

- | |
|--|
| <p>Step 1. Review key missions to identify opportunities for enhancement. Prioritize.</p> <p>Step 2. In areas where opportunities exist, analyze for risk barriers.</p> <p>Step 3. When barriers are found, apply the ORM process.</p> <p>Step 4. When available ORM processes can't breakthrough, innovate!</p> <p>Step 5. When a barrier is breached, push through until a new barrier is reached.</p> |
|--|

A2.B.16.6. **RESOURCES.** The opportunity assessment depends on a detailed understanding of mission processes so that barriers can be identified. An effective opportunity assessment will necessarily involve the input of operations experts.

A2.B.16.7. **COMMENTS.** Properly implemented, at least half the value of ORM should be realized in the form of expanded mission capabilities. The opportunity assessment is a process by which that benefit is achieved.

A2.B.16.8. **EXAMPLES.** An example of the opportunity assessment in action is provided at Figure A2.35.

Figure A2.35. Example Opportunity Analysis.

Target: Crew endurance

Objective: Extend crew endurance by 15% as a contingency capability. Current capabilities are restricted by the progressively increasing risk of human error as operations are extended.

Potential operational benefit. A surge capability of 15% over and above that currently recognized could represent a decisive capability when confronted with a critical operational need.

Risk issues to be targeted:

1. Benchmark all available research and operational sources for background on the fatigue issue.
2. Determine the differential endurance capabilities of individual personnel and effective ways to measure this differential in a combat environment.
3. Assess the full potential of medicinal options (particularly recent developments) for performance enhancement.
4. Evaluate the increased use of automated flight to reduce pilot fatigue and evaluate fully the impact of progress made to date.
5. Enhance the quality of rest opportunities for crews through application of technology.
6. Exploit research on the impact of fatigue and the critical risk issues it creates.
7. Establish fatigue-connected risk assessments for major operational activities and use these as guides for use on specific operations. For example, use time multipliers for high task activities or missions.
8. Refine understanding of the types of fatigue (e.g. physical, mental, jet lag, etc.) and the varying risk implications of each.
9. Develop easy-to-use job aids, tools, and model programs to guide field personnel in the full scope of fatigue management issues.
10. Develop programmatic matrices that effectively assess in an ongoing way the impact of all fatigue management initiatives.

SECTION A2.C. THE ADVANCED HAZARD IDENTIFICATION TOOLS

A2.C.1. The five tools that follow are advanced hazard identification tools designed to support strategic hazard analysis of higher risk and mission critical operations. These advanced tools are often essential when in-depth hazard ID is needed. These advanced tools provide the mechanism needed to push the limits of current hazard identification technology. For example, the management oversight and risk tree (MORT) represents the full-time efforts of dozens of experts over decades to fully develop an understanding of all of the sources of hazards.

A2.C.2. As might be expected, these tools are complex and require significant training to use. Full proficiency also requires experience in using the tools. As a result, these tools are generally used exclusively by loss control professionals. Of course personnel with an engineering, scientific, or other technical background are certainly capable of using these tools with a little read-in. Even though the tools are used by professionals much of the data that must be fed into the procedures must come from operators.

A2.C.3. In an organization with a mature ORM culture, all personnel in the organization will be aware that higher risk justifies more extensive hazard identification. They will feel comfortable calling for help from various loss control professionals, confident that these individuals have the advanced hazard ID tools needed to cope with the most serious risk situations. These advanced tools will play a key role in the mature ORM culture in helping the organization reach its hazard ID goal: No significant hazard undetected.

A2.C.4. THE ENERGY TRACE AND BARRIER ANALYSIS

A2.C.4.1. FORMAL NAME. The energy trace and barrier analysis

A2.C.4.2. ALTERNATIVE NAMES. None

A2.C.4.3. PURPOSE. The energy trace and barrier analysis (ETBA) is a professional level procedure intended to detect hazards by focusing in detail on the presence of energy in a system and the barriers for controlling that energy. It is conceptually similar to the interface analysis in its focus on energy forms, but is considerably more thorough and systematic.

A2.C.4.4. APPLICATION. The ETBA is intended for use by loss control professionals and is targeted against higher risk operations, especially those involving large amounts of energy or a wide variety of energy types. The method is used extensively in the acquisition of new weapons systems and other complex systems.

A2.C.4.5. METHOD. The ETBA involves 5 basic steps as shown at Figure A2.36. Step 1 is the identification of the types of energy found in the system. It often requires considerable expertise to detect the presence of the types of energy listed at Figure A2.37. Step 2 is the trace step. Once identified as present, the point of origin of a particular type of energy must be determined and then the flow of that energy through the system must be traced. In Step 3 the barriers to the unwanted release of that energy must be analyzed. For example, electrical energy is usually moved in wires with an insulated covering. In Step 4 the risk of barrier failure and the unwanted release of the energy is assessed. Finally, in Step 5, risk control options are considered and selected.

Figure A2.36. ETBA Steps.

- | |
|---|
| <p>Step 1. Identify the types of energy present in the system</p> <p>Step 2. Locate energy origin and trace the flow</p> <p>Step 3. Identify and evaluate barriers (mechanisms to confine the energy)</p> <p>Step 4. Determine the risk (the potential for hazardous energy to escape control and damage something significant)</p> <p>Step 5. Develop improved controls and implement as appropriate</p> |
|---|

Figure A2.37. Types of Energy.

Electrical
Kinetic (moving mass e.g. a vehicle, a machine part, a bullet)
Potential (not moving mass e.g. a heavy object suspended overhead)
Chemical (e.g. explosives, corrosive materials)
Noise and Vibration
Thermal (heat)
Radiation (Nonionizing e.g. microwave, and ionizing e.g. nuclear radiation, x-rays)
Pressure (air, water)

A2.C.4.6. **RESOURCES.** This tool requires sophisticated understanding of the technical characteristics of systems and of the various energy types and barriers. Availability of a safety professional, especially a safety engineer or other professional engineer is important.

A2.C.4.7. **COMMENTS.** All mishaps involve the unwanted release of one kind of energy or another. This fact makes the ETBA a powerful hazard ID tool. When the risk stakes are high and the system is complex, the ETBA is a must have.

A2.C.4.8. **EXAMPLES.** A simplified (no use of electrical schematics) example of the ETBA procedure is provided at Figure A2.38.

Figure A2.38. Example ETBA.

Scenario: The supervisor of a maintenance facility has just investigated a serious incident involving one of his personnel who received a serious shock while using a portable power drill in the maintenance area. The tool involved used a standard three prong plug. Investigation revealed that the tool and the receptacle were both functioning properly. The individual was shocked when he was holding the tool and made contact with a piece of metal electrical conduit (same one his drill was plugged into) that had become energized as a result of an internal fault. As a result the current flowed through the individual to the tool and through the grounded tool to ground resulting in the severe shock. The supervisor decides to fully assess the control of electrical energy in this area.

Option 1. Three prong tool. Electrical energy flow is from the source through an insulated wire, to the tool, to a single insulated electric motor. In the event of an internal fault the flow is from the case of the tool through the ground wire to ground through the grounded third prong through a properly grounded receptacle. Threats: Receptacle not properly grounded, third prong removed, person provides lower path of resistance, break in any of the ground paths (case, cord, plug, receptacle). These threats are serious in terms of the frequency encountered in the work environment and might be expected to be present in 10% or more cases.

Option 2. Double insulated tool. The tool is not grounded. Protection is provided by double insulating the complete flow of electrical energy at all points in the tool. In the event of an internal fault, there are two layers of insulation protection between the fault and the person preventing shorting through the user. Threats: If the double layers of insulation are damaged as a result of extended use, rough handling, or repair/maintenance activity, the double insulation barrier can be compromised. In the absence of a fully effective tool inspection and replacement program such damage is not an unusual situation.

Option 3. Circuit Fault Interrupters. Either of the above types of tools are used (double insulated is preferred). Electrical energy flows as described above in both the normal and fault situations. However, in the event of a fault (or any other cause of a differential between the potential and ground side of a circuit), it is detected almost instantly and the circuit is opened preventing the flow of dangerous amounts of current. Because no dangerous amount of current can flow the individual using the tool is in no danger of shock. Circuit interrupters are reliable at a level of 1 in 10,000 or higher and when they do fail, most failure modes are in the fail safe mode. Circuit fault interrupters are inexpensive to purchase and relatively easy to install.

In this case, the best option is very likely to be the use of the circuit interrupter in connection with either Option 1 or 2, with 2 the preferred. This combination for all practical purposes eliminates the possibility of electric shock and injury/death as a result of using portable power tools.

A2.C.5. THE FAULT TREE ANALYSIS

A2.C.5.1. FORMAL NAME. The fault tree analysis

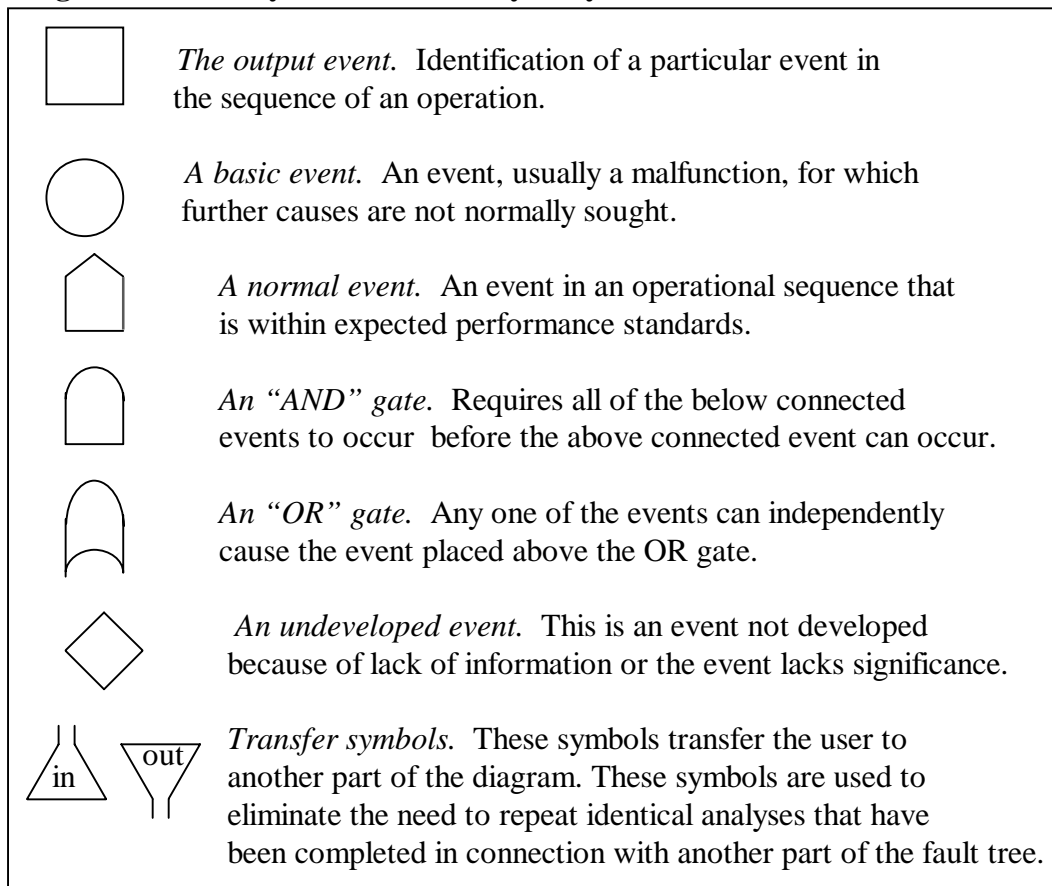
A2.C.5.2. ALTERNATIVE NAMES. The probabilistic logic tree

A2.C.5.3. PURPOSE. The fault tree analysis (FTA) is a professional-level hazard ID tool based on the negative type logic diagram. The FTA adds several dimensions to the basic logic tree. The most important of these additions are the use of symbols to add information to the trees and the possibility of adding quantitative risk data to the diagrams. With these additions, the FTA adds substantial hazard ID value to the basic logic diagram previously discussed.

A2.C.5.4. APPLICATION. Because of its relative complexity and detail, it is normally not cost effective to use the FTA against risks assessed below the level of extremely high or high. The method is used extensively in the acquisition of new weapons systems and other complex systems where, due to the complexity and criticality of the system, the tool is a must.

A2.C.5.5. METHOD. The FTA is constructed exactly like a negative logic diagram except that the symbols depicted in Figure A2.39 are used.

Figure A2.39. Key Fault Tree Analysis Symbols.

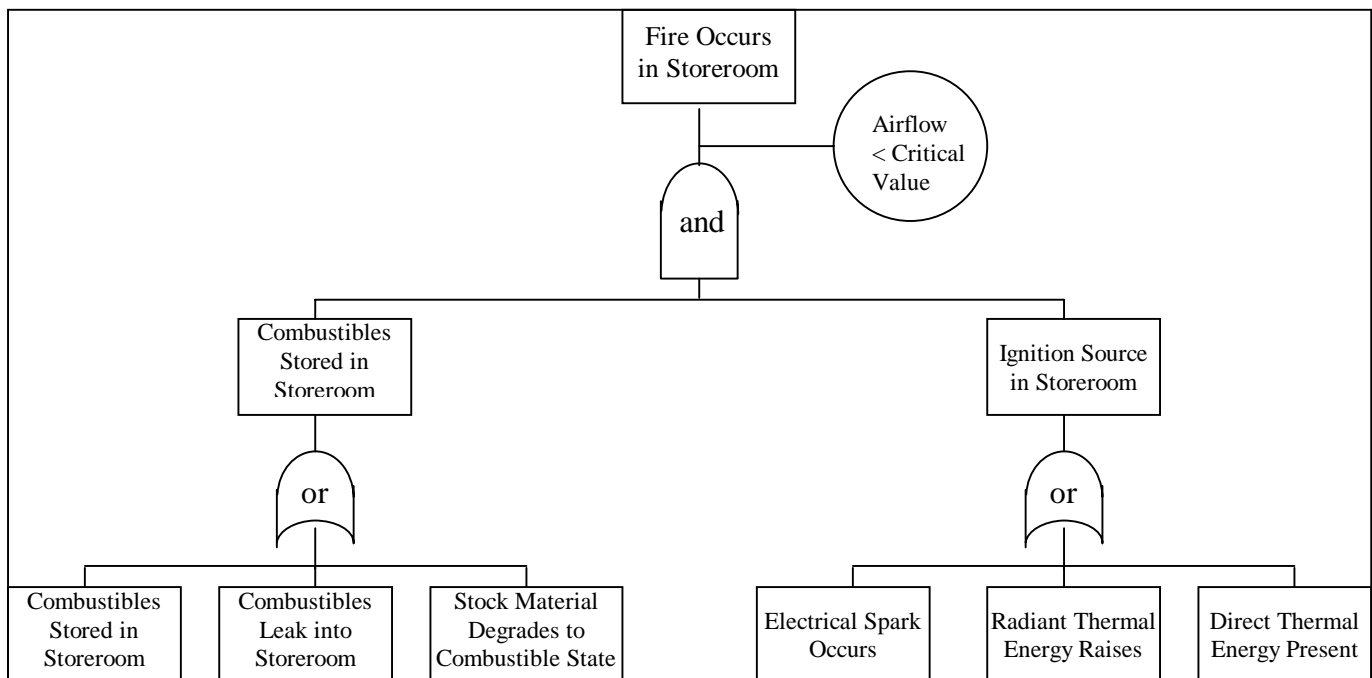


A2.C.5.6. **RESOURCES.** Your supporting safety office is the best source of information regarding fault tree analysis. Like the other more advanced tools, using the FTA will normally involve the consultation of a safety professional or engineer trained in the use of the tool. If the probabilistic aspects are added, it will also require a relatively sophisticated database capable of supplying the detailed data needed.

A2.C.5.7. **COMMENTS.** The FTA is one of the few hazard ID procedures that will support quantification when the necessary data resources are available.

A2.C.5.8. **EXAMPLE.** A basic example of the FTA is provided at Figure A2.40. Please note the example is not fully developed as it is intended as a brief example of the tool. It illustrates how an event may be traced to specific causes that can be very precisely identified at the lowest levels.

Figure A2.40. Key Fault Tree Analysis Symbols.



A2.C.6. THE FAILURE MODE AND EFFECTS ANALYSIS

A2.C.6.1. FORMAL NAME. The failure mode and effects analysis

A2.C.6.2. ALTERNATIVE NAMES. The FMEA

A2.C.6.3. PURPOSE. The failure mode and effects analysis (FMEA) is a professional level hazard ID tool specifically designed to detect and evaluate the impact due to the failure of various system components. Most FMEAs have traditionally been directed at the failure of parts in mechanical system, but the tool is suitable for analyzing the failure of any component of any type of system. A brief example of FMEA illustrating this purpose is the analysis of the impact of the failure of the communications component (radio, landline, computer, etc.) of a system on the overall mission. The focus of the FMEA is on how such a failure could occur (failure mode) and the mission impact of such a failure (effects).

A2.C.6.4. APPLICATION. The FMEA is generally regarded as a professional tool but with the assistance of the FMEA job aid, most operational personnel can use the tool effectively. The FMEA can be thought of as a more formal and detailed “What if” analysis. It is an especially useful tool in contingency planning where it is used to evaluate the impact of various possible failures (contingencies). The FMEA can be used in place of the what if analysis when greater detail is needed or it can be used to examine the impact of hazards developed using the what if tool in much greater detail.

A2.C.6.5. METHOD. The FMEA is normally accomplished using a worksheet similar to the one illustrated at Figure A2.41. As noted on the sample worksheet, a specific component of the system to be analyzed is identified. Several components can be analyzed. For example, a rotating part might freeze up, explode, breakup, slow down, or even reverse direction. Each of these failure modes may have differing impacts on connected components and the overall system. The worksheet then calls for an assessment of probability.

Figure A2.41. Sample Failure Mode and Effects Analysis Worksheet.

FAILURE MODE AND EFFECTS ANALYSIS						
System_____				Page ____ of ____ Pages		
Subsystem _____				Date_____		
				Analyst_____		
Component Description	Failure Mode	Effects on Other Components	Effects on System	RAC or Hazard Category	Failure Frequency Effects Probability	Remarks

A2.C.6.6. RESOURCES. The best source of more detailed information on the FMEA is the supporting safety office.

A2.C.6.7. COMMENTS. None

A2.C.6.8. EXAMPLES. A basic example of the FMEA is provided at Figure A2.42.

Figure A2.42. Example FMEA.

<p>Situation: The chief of a major small arms training facility is concerned about the possible impact of the failure of the landline communications system that provides the sole communications capability at the site. The decision is made to do a failure mode and effects analysis. An extract from the resulting FMEA is shown below.</p>						
Component	Function	Failure Mode & Cause	Failure Effect on		Probability	Corrective action
			Higher Item	System		
Landline Wire	Comm	Cut -natural cause, Falling tree, etc.	Comm sys down	Cease Fire	Probable	Clear natural obstacles from around wires
Wire		Cut - unrelated operational activities	Comm sys down	Cease Fire	Probable	Warn all operations Placement of wire
Wire		Line failure	Comm sys down	Cease Fire	Probable	Placement of wires Proper grounding
Wire		Cut - vandals & thieves	Comm sys down	Cease Fire	Unlikely	Placement of wires Area security

A2.C.7. THE MULTILINEAR EVENTS SEQUENCING TOOL

A2.C.7.1. FORMAL NAME. The multilinear events sequencing tool

A2.C.7.2. ALTERNATIVE NAMES. The timeline tool, the sequential time event plot (STEP)

A2.C.7.3. PURPOSE. The multilinear events sequencing tool (MES) is a highly specialized hazard ID procedure designed to detect hazards arising from the time relationship of various operational activities. The MES detects situations in which either the absolute timing of events or the relational timing of events may create risk. For example, an operational planner may have crammed too many events into a single period of time, creating a task overload problem for the personnel involved. Alternatively, the MES may reveal that two or more events in an operational plan conflict because a person or piece of equipment is required for both but obviously can't be in two places at once. The MES can be used as a hazard ID tool or as a mishap investigation tool.

A2.C.7.4. APPLICATION. The MES is usually considered a professional loss prevention level tool, but the MES worksheet actually simplifies the process to the point that a motivated individual can effectively use the tool. The MES should be used any time that risk levels are significant and when timing and/or time relationships may be a source of risk. It is almost an essential tool when the time relationships are relatively complex.

A2.C.7.5. METHOD. The MES is accomplished using a worksheet similar to the one illustrated at Figure A2.43. The sample worksheet displays the timeline of the operation across the top and the "actors" (people or things) down the left side. Notice that in some operations the timeline may literally be broken down in seconds. The flow of events is then displayed on the worksheet showing the relationship between the actors on a time basis. Once the operation is displayed on the worksheet, the sources of risk will be evident as the flow is examined.

Figure A2.43. Multi-linear Events Sequencing Form.

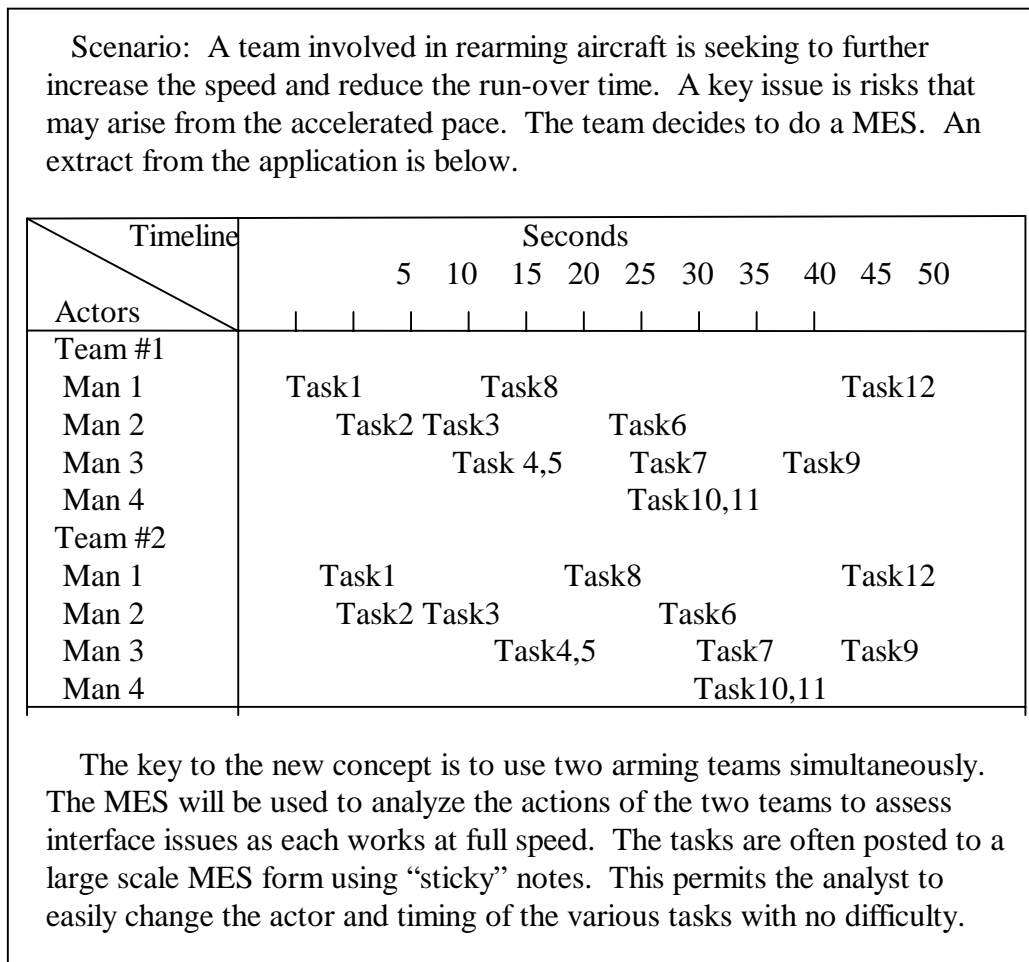
Timeline Actors (People or things involved in the process)	(Time units in seconds or minutes as needed)

A2.C.7.6. RESOURCES. The best sources for more detailed information on the MES is the local safety staff. As with the other more advanced tools, using the MES will normally involve consultation with a safety professional familiar with its application.

A2.C.7.7. COMMENTS. The MES is unique in its role of examining the time-risk implications of operations.

A2.C.7.8. EXAMPLE. A simplified example of the MES is provided at Figure A2.44.

Figure A2.44. Example MES.



A2.C.8. THE MANAGEMENT OVERSIGHT AND RISK TREE

A2.C.8.1. FORMAL NAME. The management oversight and risk tree

A2.C.8.2. ALTERNATIVE NAMES. The MORT

A2.C.8.3. PURPOSE. The management oversight and risk tree (MORT) is the ultimate hazard ID tool. MORT uses a series of MORT charts developed and perfected over several years by the Department of Energy in connection with their nuclear safety programs. Each MORT chart identifies a potential operating or management level hazard that might be present in an operation. The attention to detail characteristic of MORT is illustrated by the fact that the full MORT diagram or tree contains more than 10,000 blocks. Even the simplest MORT chart contains over 300 blocks. Obviously, full application of MORT is a very time-consuming and costly venture. The basic MORT chart with about 300 blocks can be routinely used as a check on the other hazard ID tools. By reviewing the major headings of the MORT chart, an analyst will often be reminded of a type of hazard that was overlooked in the initial analysis. The MORT diagram is also very effective in assuring attention to the underlying management root causes of hazards.

A2.C.8.4. APPLICATION. Full application of MORT is reserved for the highest risks and most mission critical activities because of the time and expense required. MORT is also basically a professional tool requiring a specially trained loss control professional to assure proper application. The basic MORT diagram can be used to facilitate and check on the overall hazard ID process by those with the interest and motivation to ensure excellence.

A2.C.8.5. METHOD. MORT is accomplished using the MORT diagrams. As indicated above there are several levels of the MORT diagram available. The most comprehensive, with about 10,000 blocks basically fills a book. There is an intermediate diagram with about 1500 blocks, and a basic diagram with about 300. Of course it is possible to tailor a MORT diagram by choosing various branches of the MORT tree and using only those segments. The MORT is essentially a negative tree, so the process begins by placing an undesired loss event at the top of the diagram used. The MORT user then systematically responds to the issues posed by the MORT diagram. All aspects of the diagram are considered and the "less than adequate" blocks are highlighted for risk control action.

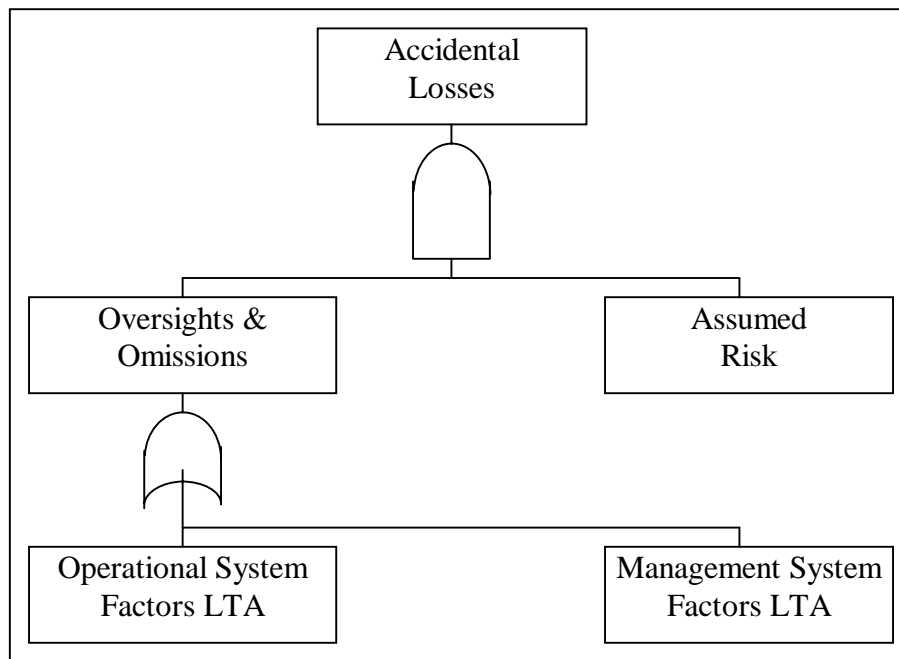
A2.C.8.6. RESOURCES. The best source of information on MORT is the supporting safety office.

A2.C.8.7. COMMENTS. MORT is the ultimate in ORM hazard ID processes. Unfortunately, in a military context only rarely will the time, resources, expertise, and mission critical issue come together to permit full application of the process. Nevertheless, the wise risk manager will become familiar with MORT processes and will frequently use the basic MORT diagram to reinforce mainstream hazard ID tools.

The MORT diagram is essentially an elaborate negative logic diagram. The difference is primarily that the MORT diagram is already fill-out for the user, allowing a person to identify various contributory cause factors for a given undesirable event. Since the MORT is very detailed, as mentioned above, a person can identify basic causes for essentially any type of event.

A2.C.8.8. EXAMPLES. The top blocks of the MORT diagram are displayed at Figure A2.45.

Figure A2.45. Example MORT Section.



Attachment 3

RISK ASSESSMENT TOOLS, DETAILS, AND EXAMPLES

A3.1. Introduction. There are many ways to assess risk, but the easiest and most effective for routine risk management applications is the risk assessment matrix introduced in *Section D*. The easiest way to understand the application of the matrix is to apply it. Follow the reasoning of the matrix user in the example below as he applies the matrix to the assessment of the hazards associated with the movement of a heavy machine from point A to point B.

A3.1.1. Example. The example below demonstrates the application of the matrix to a hazard associated with moving a heavy piece of machinery.

A3.1.1.1. Hazard to be assessed: The hazard of the machine falling over and injuring personnel.

A3.1.1.2. Probability assessment: The following paragraphs illustrate the thinking process that might be followed in developing the probability segment of the risk assessment:

A3.1.1.2.1. Use previous experience and the database, if available. “We moved a similar machine once before and although it did not fall over, there were some close calls. This machine is not as easy to secure as that machine and has a higher center of gravity and poses an even greater chance of falling. The base safety office indicates that there was a mishap about 18 months ago that involved a similar operation. An individual received a broken leg in that case.”

A3.1.1.2.2. Use the output of the hazard analysis process. “Our hazard analysis shows that there are several steps in the machine movement process where the machine is vulnerable to falling. Furthermore, there are several different types of failures that could cause the machine to fall. Both these factors increase the probability of falling.”

A3.1.1.2.3. Consider expert opinion. “My experienced NCOs feel that there is a real danger of the machine falling”

A3.1.1.2.4. Consider your own intuition and judgment. “My gut feeling is that there is a real possibility we could lose control of this machine and topple it. The fact that we rarely move machines quite like this one increases the probability of trouble.”

A3.1.1.2.5. Refer to the matrix terms. “Hmmm, the decision seems to be between *likely* and *occasional*. I understand *likely* to mean that the machine is likely to fall, meaning a pretty high probability. Certainly there is a real chance it may fall, but if we are careful, there should be no problem. I am going to select *Occasional* as the best option from the matrix.”

A3.1.1.3. Severity assessment. The following illustrates the thinking process that might occur in selecting the severity portion of the risk assessment matrix for the machine falling hazard:

A3.1.1.3.1. Identify likely outcomes. “If the machine falls, it will crush whatever it lands on. Such an injury will almost certainly be severe. Because of the height of the machine, it can easily fall on a person’s head and body with almost certain fatal results. There are also a variety of different crushing injuries, especially of the feet, even if the machine falls only a short distance.

A3.1.1.3.2. Identify the most likely outcomes. “Because of the weight of the machine, a severe injury is almost certain. Because people are fairly agile and the fact that the falling machine gives a little warning that it is falling, death is not likely.”

A3.1.1.3.3. Consider factors other than injuries. “We identified several equipment and facility items at risk. Most of these we have guarded, but some are still vulnerable. If the machine falls nobody can do any thing to protect these items. It would take a couple of days at least to get us back in full production.”

A3.1.1.3.4. Refer to the matrix (see Figure A3.1). “Let’s see, any injury is likely to be severe, but a fatality is not very probable, property damage could be expensive and could cost us a lot of production time. Considering both factors, I think that *critical* is the best choice.”

A3.1.1.4. Combine probability and severity in the matrix. The thinking process should be as follows:

A3.1.1.4.1. The probability category *occasional* is in the middle of the matrix (refer to the matrix below). I go down until it meets the *critical* category coming from the left side. The result is a *high* rating. I notice that it is among the lower *high* ratings but it is still *high*.”

Figure A3.1. Risk Assessment Matrix.

			Probability				
			Frequent	Likely	Occasional	Seldom	Unlikely
			A	B	C	D	E
S E V E R I T Y	Catastrophic	I	Extremely				
	Critical	II	High	High			
	Moderate	III		Medium			
	Negligible	IV		Low			
			Risk Levels				

A3.2. Limitations and concerns with the use of the matrix. As you followed the scenario above, you may have noted that there are some problems involved in using the matrix. These include the following:

A3.2.1. Subjectivity. There are at least two dimensions of subjectivity involved in the use of the matrix. The first is in the interpretation of the matrix categories. Your interpretation of the term “critical” may be quite different from mine. The second is in the interpretation of the hazard. If a few weeks ago I saw a machine much like the one to be moved fall over and crush a person to death, I might have a greater tendency to rate both the probability and severity higher than someone who did not have such an experience. If time and resources permit, this variation can be reduced by averaging the rating of several personnel.

A3.2.2. Inconsistency. The subjectivity described above naturally leads to some inconsistency. A hazard rated very high in one organization may only have a high rating in another. This becomes a real problem if the two hazards are competing for a limited pot of risk control resources (as they always are). There will be real motivation to inflate risk assessments to enhance competitiveness for limited resources.

A3.2.3. Lack of a range of rankings. The standard matrix produces only four level of risk i.e. EH, H, M and L. The highest level, EH, will normally be corrected almost immediately. The lowest level, L, are often so minor that they do not warrant serious consideration. This means that the vast majority of meaningful hazards are either H or M. When we try to construct a risk totem pole we are still faced with a big prioritization problem since most meaningful risks are in only two categories. An option to overcome this problem is to assign numbers to each block of the matrix. These numbers can then be used to augment the basic categories. An example is shown below in Figure A3.2. Note that the modified matrix provides 20 levels of risk. Note that the numbers do not replace the basic EH, H, M and L categories, they augment them. Additionally, be aware that although the levels are arranged so that the higher risks have a low number, the matrix can be constructed so high numbers reflect higher risk levels. Use whichever method best suits your organizational needs without creating a conflict.

Figure A3.2. Modified Risk Matrix.

			Probability				
			Frequent	Likely	Occasional	Seldom	Unlikely
			A	B	C	D	E
S E V E R E R I S K T Y	Catastrophic	I	1	2	6	8	12
	Critical	II	3	4	7	11	15
	Moderate	III	5	9	10	14	16
	Negligible	IV	13	17	18	19	20
			Risk Levels				

A3.3. The risk totem pole. The risk totem pole is designed to display the hazards of an operation in a top down order of priority. The highest risk hazard is placed at the top of the totem pole with progressively less risky hazards displayed in order of priority below it. All hazards are displayed on the totem pole until the risk is so low that the hazards are not likely to warrant any expenditures of resources to control them. It is desirable to indicate the risk rating (extremely high, high, medium, low) for hazards by either labeling each hazard or by labeling each group. The totem pole is used to assure that risk issues are attacked on the basis of worst first and that the greatest resource expenditures are focused on the worst hazards.

A3.3.1. Figure A3.3 is an abbreviated example of a totem pole for the machine movement example.

Figure A3.3. Example Risk Totem Pole.

Extremely high risks:	None.
High risks:	Personnel injured by falling machine during forklift operations. Personnel injured by falling machine during initial lift. Personnel injured by falling machine during final placement. Damage to critical facilities (welding station, etc.) during initial lift.
Medium risks:	Damage to the machine due to a fall. Damage and/or injury during truck movement. Damage to the machine during handling operations. Strain and sprain injuries to personnel during the lift phases.
Low risks:	Minor personnel injuries due to cuts, abrasions, etc. Minor machine or facility damage due to machine handling.

A3.3.2. Use of the totem pole. Because the totem pole lists all the hazards in order of importance, it helps to prioritize risk control efforts. This is the basic purpose of the totem pole, but it can do other things for us. For example, it is also useful to see different hazards that may be attacked with a single risk control. In the example above, several hazards arise from the potential of the heavy, unstable machine to fall over causing injury or damage. One potential risk control - attaching the machine to a wider, more stable base before lifting and moving it may reduce the risk from all these related issues. We can also use the risk totem pole to break the overall list of hazards out into clusters of related risk issues so that the responsible personnel for those areas can address them in order of priority. This can be a positive step toward integration of risk management roles.

Attachment 4

RISK CONTROL OPTION ANALYSIS TOOLS, DETAILS, AND EXAMPLES

SECTION A4.1. BASIC RISK CONTROL OPTIONS

A4.A.1. There are several ways we can deal with risk. The major risk control options and examples of each are as follows:

A4.A.1.1. **Reject** a risk. We can and should refuse to take a risk if the overall costs of the risk exceed its mission benefits. For example, an operational planner may review the risks associated with a specific ground attack profile for a particular aircraft type. After assessing all the advantages of this profile and evaluating the increased risk associated with it, even after application of all available risk controls, he decides the benefits do not outweigh the expected risk costs and the unit is better off in the long run not using that profile.

A4.A.1.2. **Avoiding** risk altogether requires canceling or delaying the job, mission, or operation, but is an option that is rarely exercised due to mission importance. However, it may be possible to avoid specific risks: risks associated with a night operation may be avoided by planning the operation for daytime, likewise thunderstorm or surface-to-air-missile risks can be avoided by changing the route of flight.

A4.A.1.3. **Delay** a risk. It may be possible to delay a risk. If there is no time deadline or other operational benefit to speedy accomplishment of a risky task, then it is often desirable delay the acceptance of the risk. During the delay, the situation may change and the requirement to accept the risk may go away. During the delay additional risk control options may become available for one reason or another (resources become available, new technology becomes available, etc.) thereby reducing the overall risk. For example, a commander may be required to hold a certain type of risky emergency action training for personnel assigned to a special mission. All things being equal, it might be a good idea to schedule this training relatively late in the mission preparation cycle. The mission may well be canceled or changed in such a way that the training is not needed.

A4.A.1.4. Risk **transference** does not change probability or severity of the hazard, but it may decrease the probability or severity of the risk actually experienced by the individual or organization accomplishing the mission/activity. As a minimum, the risk to the original individual or organization is greatly decreased or eliminated because the possible losses or costs are shifted to another entity. An example is deciding to fly an Unmanned Aerial Vehicle into a high risk environment instead of risking personnel in a manned aircraft.

A4.A.1.5. Risk is commonly **spread** out by either increasing the exposure distance or by lengthening the time between exposure events. Chaff, flares, and decoys provide additional targets for enemy weapons and effectively spread out the risk of strike on an aircraft. Aircraft may be parked so that an explosion or fire in one aircraft will not propagate to others. Risk may also be spread over a group of personnel by rotating the personnel involved in a high risk operation.

A4.A.1.6. **Compensate** for a risk. We can create a redundant capability in certain special circumstances. Flight control redundancy is an example of an engineering or design redundancy. Another example is to

plan for a back-up, then when a critical piece of equipment or other mission asset is damaged or destroyed we have capabilities available to bring on line to continue the mission.

A4.A.1.7. Risk can be **reduced**. The overall goal of risk management is to plan missions or design systems that do not contain hazards. However, the nature of most complex missions and systems makes it impossible or impractical to design them completely hazard-free. As hazard analyses are performed, hazards will be identified that will require resolution. To be effective, risk management strategies must address the components of risk: probability, severity, or exposure. A proven order of precedence for dealing with hazards and reducing the resulting risks is:

A4.A.1.7.1. *Plan or Design for Minimum Risk*. From the first, plan the mission or design the system to eliminate hazards. Without a hazard there is no probability, severity or exposure. If an identified hazard cannot be eliminated, reduce the associated risk to an acceptable level. Flight control components can be designed so they cannot be incorrectly connected during maintenance operations as an example.

A4.A.1.7.2. *Incorporate Safety Devices*. If identified hazards cannot be eliminated or their associated risk adequately reduced by modifying the mission or system elements or their inputs, that risk should be reduced to an acceptable level through the use of safety design features or devices. Safety devices usually do not effect probability but reduce severity: an automobile seat belt doesn't prevent a collision but reduces the severity of injuries. Nomex gloves and steel toed boots won't prevent the hazardous event, or even change the probability of one occurring, but they prevent, or decrease the severity of, injury. Physical barriers fall into this category.

A4.A.1.7.3. *Provide Warning Devices*. When mission planning, system design, and safety devices cannot effectively eliminate identified hazards or adequately reduce associated risk, warning devices should be used to detect the condition and alert personnel of the hazard. As an example, aircraft could be retrofitted with a low altitude ground collision warning system to reduce controlled flight into the ground mishaps. Warning signals and their application should be designed to minimize the probability of the incorrect personnel reaction to the signals and should be standardized. Flashing red lights or sirens are a common warning device that most people understand.

A4.A.1.7.4. *Develop Procedures and Training*. Where it is impractical to eliminate hazards through design selection or adequately reduce the associated risk with safety and warning devices, procedures and training should be used. A warning system by itself may not be effective without training or procedures required to respond to the hazardous condition. The greater the human contribution to the functioning of the system or involvement in the mission process, the greater the chance for variability. However, if the system is well designed and the mission well planned, the only remaining risk reduction strategies may be procedures and training. Emergency procedure training and disaster preparedness exercises improve human response to hazardous situations.

A4.A.2. In most cases it will not be possible to eliminate risk entirely, but it will be possible to significantly reduce it. There are many risk reduction options available. These have been captured in the sample Risk Control Options Matrix, provided in .

SECTION A4.B. THE RISK CONTROL OPTIONS MATRIX

A4.B.1. The sample risk control options matrix, illustrated at Figure A4.1, is designed to develop a detailed and comprehensive list of risk control options. These options are listed in priority order of preference, all things being equal, therefore start at the top and consider each option in turn. Add those controls that appear suitable and practical to a list of potential options. Examples of each control option are suggested in Figure A4.2. Notice that many of the options may be applied at more than one level. For example, the training option may be applied to operators, supervisors, more senior leaders, or staff personnel.

Figure A4.1. Sample Risk Control Options Matrix.

OPTIONS	OPERATOR	LEADER	STAFF	CMDR
ENGINEER (Energy Mgt)				
Limit Energy				
Substitute Safer Form				
Prevent Buildup				
Prevent Release				
Provide Slow Release				
Rechannell/separate In Time/Space				
Provide Special Maint of Controls				
GUARD				
On Source				
Barrier Between				
On Human or Object				
Raise Threshold (harden)				
IMPROVE TASK DESIGN				
Sequence of Events (Flow)				
Timing (within tasks, between tasks)				
Man-Machine Interface/Ergonomics				
Simplify Tasks				
Reduce Task Loads				
(physical, mental, emotional)				
Backout Options				
LIMIT EXPOSURE				
Number of People or Items				
Time				
Iterations				
SELECTION OF PERSONNEL				
Mental Criteria				
Emotional Criteria				
Physical Criteria				
Experience				
TRAIN AND EDUCATE				
Core Tasks (especially critical tasks)				
Leader Tasks				
Emergency/Contingency Tasks				
Safety Tasks				
Rehearsals				
WARN				
Signs/Color Coding				
Audio/Visual Alarms				
Briefings				
MOTIVATE				
Measurable Standards				
Essential Accountability				
Positive/negative Incentives				
Competition				
Demonstrations of Effects				
REDUCE EFFECTS				
Emergency Equipment				
Rescue Capabilities				
Emergency Medical Care				
Emergency Procedures				
Damage Control Procedures/Plans				
Backups/Redundant Capabilities				
REHABILITATE				
Personnel				
Facilities/equipment				
Mission Capabilities				

Figure A4.2. Example Risk Control Options Matrix.

OPTIONS	SOME EXAMPLES
ENGINEER (Energy Mgt).	
Limit Energy	Lower voltages, small amount of explosives, reduce heights, reduce speeds
Substitute Safer Form	Use air power, less hazardous chemicals, more stable explosives/chemicals
Prevent Buildup	Use automatic cutoffs, blowout panels, limit momentum, governors
Prevent Release	Containment, double/triple containment
Provide Slow Release	Use pressure relief valves, energy absorbing materials
Rechannel/separate In Time/Space	Automatic processes, diverters, barriers, distance
Provide Special Maint of Controls	Special procedures, special checks/audits
GUARD.	
On Source	Fire suppression systems, energy absorbing systems (crash walls, etc.)
Barrier Between	Revetments, walls, distance
On Human or Object	Personal protective equipment, energy absorbing materials
Raise Threshold (harden)	Acclimatization, over-design, reinforcement, physical conditioning
IMPROVE TASK DESIGN.	
Sequence of Events (Flow)	Put tough tasks first before fatigue, don't schedule several tough tasks in a row
Timing (within tasks, between tasks)	Allow sufficient time to perform, to practice. Allow adequate time between tasks
Man-Machine Interface/Ergonomics	Assure equipment fits the people, and effective ergonomic design
Simplify Tasks	Provide job aids, reduce steps, provides tools like lifters communications aids
Reduce Task Loads	Set weight limits, automate mental calculations and some monitoring tasks
(physical, mental, emotional)	Avoid excessive stress, provide breaks, vacations, spread risk among many
Backout Options	Establish points where process reversal is possible when hazard is detected
LIMIT EXPOSURE.	
Number of People or Items	Only expose essential personnel & things
Time	Minimize the time of exposure - Don't bring the explosives until the last minute
Iterations	Don't do it as often
SELECTION OF PERSONNEL.	
Mental Criteria	Essential basic intelligence, and essential skills and proficiency
Emotional Criteria	Essential stability and maturity
Physical Criteria	Essential strength, motor skills, endurance, size
Experience	Demonstrated performance abilities
TRAIN AND EDUCATE.	
Core Tasks (especially critical tasks)	Define critical minimum abilities, train, test and score
Leader Tasks	Define essential leader tasks and standards, train, test and score
Emergency Contingency Tasks	Define, assign, train, verify ability
Safety Tasks	Hazard ID, risk controls, maintenance of standards
Rehearsals	Validate processes, validate skills, verify interfaces
WARN.	
Signs/Color Coding	Warning signs, instruction signs, traffic signs
Audio/Visual Alarms	Bells, flares, flashing lights, klaxons, whistles
Briefings	Refresher warnings, demonstrate hazards, refresh training
MOTIVATE.	
Measurable Standards	Define minimum acceptable risk controls, see that tasks are assigned
Essential Accountability	Check performance at an essential level of frequency and detail
Positive/negative Incentives	Meaningful individual & group rewards, punishment
Competition	Healthy individual and group competition on a fair basis
Demonstrations of Effects	Graphic, dynamic, but tasteful demonstrations of effects of unsafe acts
REDUCE EFFECTS.	
Emergency Equipment	Fire extinguishers, first aid materials, spill containment materials
Rescue Capabilities	A rescue squad, rescue equipment, helicopter rescue
Emergency Medical Care	Trained first aid personnel, medical facilities
Emergency Damage Control Procedures	Emergency responses for anticipated contingencies, coordinating agencies
Backups/Redundant Capabilities	Alternate ways to continue the mission if primaries are lost
REHABILITATE.	
Personnel	Rehabilitation services restore confidence
Facilities/equipment	Get key elements back in service
Mission Capabilities	Focus on restoration of the mission

Attachment 5

MAKE CONTROL DECISIONS TOOLS, DETAILS, AND EXAMPLES

A5.1. Introduction. The fourth step of the ORM process involves make control decisions regarding the best risk control options to actually apply. If Step 3, develop risk control options has been effectively accomplished, there should be a number of practical control options to consider. These will include the basic options (reject, transfer, spread, etc.) as well as a comprehensive list of risk reduction options generated through use of the risk control options matrix. Of course a decision requires a decisionmaker. The organization will require a procedure to establish, as a matter of routine, who should make various levels of risk decisions. Finally, after the best available set of risk controls is selected the decisionmaker will make a final go/no-go decision.

A5.2. Developing a decisionmaking process and system. Risk decisionmaking should be routinized in a risk decision system.

A5.2.1. This system will produce the following benefits:

A5.2.1.1. Promptly get decisions to the right decisionmakers

A5.2.1.2. Create a trail of accountability

A5.2.1.3. Assure that risk decisions involving comparable levels of risk are generally made at comparable levels of leadership

A5.2.1.4. Assure timely decisions

A5.2.1.5. Explicitly provide for the flexibility in the decisionmaking process required by the nature of military operations.

A5.2.2. A decision matrix is an important part of a good decisionmaking system. These are normally tied directly to the risk assessment process. An example is shown at Figure A5.1.

Figure A5.1. Example Risk Decision Making Guidance.

Risk decisions in the XX Wing will be made at the level indicated in the matrix below. When military circumstances dictate, risk decisions may be made at levels below the level indicated, subject to later review and accountability.	
RISK LEVEL	DECISION LEVEL
Extremely High	Wing Commander or specifically authorized designee
High	Group Commander or specifically authorized designee
Medium	Flight leader, or senior leader on the scene
Low	Any person in a leadership position

A5.3. Selecting the best combination of risk controls. This process can be made as simple as intuitively choosing what appears to be the best control or group of controls, or so complex they justify the use of the most sophisticated decisionmaking tools available. For most risks involving moderate levels of risk and

relatively small investments in risk controls, the intuitive method is fully satisfactory. Here are a few guidelines to keep in mind as these intuitive decisions are made.

A5.3.1. Don't select control options to produce the lowest level of risk, select the combination yielding the most mission supportive level of risk. This means keeping in mind the need to take risks when those risks are necessary for improved mission performance. Remember there is a mission risk associated with *not* taking risks that advance mission performance.

A5.3.2. Be aware that some risk controls are incompatible. In some cases using risk control A will cancel the effect of risk control B. Obviously using both A and B is wasting resources. For example, a fully effective machine guard may make it completely unnecessary to use personnel protective equipment such as goggles and face shields. Using both will waste resources and impose a burden on operators.

A5.3.3. Be aware that some risk controls reinforce each other. For example, a strong enforcement program to discipline violators of safety rules, will be complemented by a positive incentive program to reward safe performance. The impact of the two coordinated together will usually be stronger than the sum of their impacts.

A5.3.4. Evaluate full costs versus full benefits. Try to evaluate all the benefits of a risk and evaluate them against all of the costs of the risk control package. Traditionally, this comparison has been limited to comparisons of the mishap costs versus the safety function costs.

A5.3.5. When it is mission supportive, choose redundant risk controls to protect against risk in-depth. Keep in mind the objective is not risk control, it is *optimum* risk control.

A5.4. Selecting risk controls when risks are high and risk control costs are important - cost benefit assessment. In these cases, the stakes are high enough to justify application of more formal decisionmaking processes. All of the tools existing in the management science of decisionmaking apply to the process of risk decisionmaking. Two of these tools should be used routinely and deserve space in this publication. The first is cost benefit assessment, a simplified variation of cost benefit analysis. Cost benefit analysis is a science in itself, however, it can be simplified sufficiently for routine use in risk management decisionmaking even at the lowest organizational levels. Some fiscal accuracy will be lost in this process of simplification, but the result of the application will be a much better selection of risk controls than if the procedures were not used. Budget personnel are usually trained in these procedures and can add value to the application. The process involves the following steps:

A5.4.1. Step 1. Measure the full, lifecycle costs of the risk controls to include all costs to all involved parties. For example, a motorcycle helmet standard should account for the fact that each operator will need to pay for a helmet even though the Air Force does not have to pay for any.

A5.4.2. Step 2. Develop the best possible estimate of the likely lifecycle benefits of the risk control package to include any non-safety benefits expressed as a dollar estimate. For example, an ergonomics program can be expected to produce significant productivity benefits in addition to a reduction in cumulative trauma injuries.

A5.4.3. Step 3. Let your budget experts fine tune your efforts.

A5.4.4. Step 4. Develop the cost benefit ratio. You are seeking the best possible benefit-to-cost ratio but at least 2 to 1.

A5.4.5. Step 5. Fine tune the risk control package to achieve an improved “bang for the buck”. The example at Figure A5.2 illustrates this process of fine tuning applied to an ergonomics training course (risk control).

Figure A5.2. Example Maximizing Bang for the Buck.

Anyone can throw money at a problem. A real manager finds the optimum level of resources producing an optimum level of effectiveness, i.e. maximum bang for the buck. Consider an ergonomics training program involving training 400 supervisors from across the entire organization in a 4 hour (3 hours training, 1 hour admin) ergonomics training course that will cost \$30,500 including student time. Ergonomics losses have been averaging \$300,000 per year and estimates are that the risk control will reduce this loss by 10% or \$30,000. On the basis of a cost benefit assessment over the next year (ignoring any outyear considerations), this risk control appears to have a one year negative cost benefit ratio i.e. \$30,000 in benefit, versus a \$30,500 investment, a \$500 loss. Apparently it is not a sound investment on a one year basis. This is particularly true when we consider that most decision-makers will want the comfort of a 2 or 3 to 1 cost benefit ratio to insure a positive outcome. Can this project be turned into a winner?

We can make it a winner if able to access risk information concerning ergonomics injuries/illnesses from loss control office data, risk management concepts, and a useful tool called "Pareto's Law". Pareto's Law, as previously mentioned, essentially states that 80% of most problems can be found in 20% of the exposure. For example, 80% of all at fault traffic mishaps might involve only 20% of the driver population. We can use this law, guided by our injury/illness data, to turn the training program into a solid winner. Here is what we might do.

Step 1. Lets assume that Pareto's Law applies to the distribution of ergonomics problems within this organization. If so, then 80% of the ergonomics problem can be found in 20% of our exposures. Our data can tell us which 20%. We can then target the 20% (80 students) of the original 400 students that are accounting for 80% of our ergonomics costs (\$240,000).

Step 2. Lets also assume that Pareto's Law applies to the importance of tasks that we intend to teach in the training course. If the three hours of training included 10 tasks, lets assume that two of those tasks (20%) will in fact account for 80% of the benefit of the course. Again our data should be able to indicate this. Lets also assume that by good luck, these two tasks only take the same time to teach as the other eight. We might now decide to teach only these two tasks which will require only 36 minutes (20% of 180 minutes). We will still retain 80% of the \$240,000 target value or \$192,000.

Step 3. Since the training now only requires 36 minutes, we will modify our training procedure to conduct the training in the workshops rather than in a classroom. This reduces our admin time from 1 hour (wash up, travel, get there well before it actually starts, and return to work) to 4 minutes. Our total training time is now 40 minutes.

Summary. We are still targeting \$192,000 of the original \$300,000 annual loss but our cost factor is now 80 employees for 40 minutes at \$15/hour, with our teaching cost cut to 1/5th of the \$6000 (80 students instead of 400) which is \$1200. We still have our staff cost so the total cost of the project is now \$2500. We will still get the 10% reduction in the remaining \$192,000 that we are still targeting, which totals \$19,200. Our cost benefit ratio is now a robust 7.68 to 1. If all goes well with the initial training and we actually demonstrate at 20% loss reduction, we may choose to expand the training to the next riskiest 20% of our 400 personnel which should also produce a very positive return.

A5.5. Selecting risk controls when risks are high and risk control costs are important - use of decision matrices. An excellent tool for evaluating various risk control options is the decision matrix. On the vertical dimension of the matrix we list the mission supportive characteristics we are looking for in risk controls. Across the top of the matrix we list the various risk control options (individual options or packages of options). Then we rank each control option on a scale of 1 (very low) to 10 (very high) in each of the desirable characteristics. If we choose to, we can weight each desirable characteristic based on its mission significance and calculate the weighted score (illustrated below). All things being the same, the options with the higher scores are the stronger options. A generic illustration is provided at Figure A5.3.

Figure A5.3. Sample Decision Matrix.

RATING FACTOR	WEIGHT*	RISK CONTROL OPTIONS/PACKAGES					
		#1	#2	#3	#4	#5	#6
Low cost	5	9/45	6/30	4/20	5/25	8/40	8/40
Easy to implement	4	10/40	7/28	5/20	6/24	8/32	8/32
Positive operator involvement	5	8/40	2/10	1/5	6/30	3/15	7/35
Consistent with culture	3	10/30	2/6	9/27	6/18	6/18	6/18
Easy to integrate	3	9/27	5/15	6/18	7/21	6/18	5/15
Easy to measure	2	10/20	10/20	10/20	8/16	8/16	5/10
Low risk (sure to succeed)	3	9/27	9/27	10/30	2/6	4/12	5/15
TOTALS		229	136	140	140	151	165
* Weighting is optional and is designed to reflect the relative importance of the various factors.							

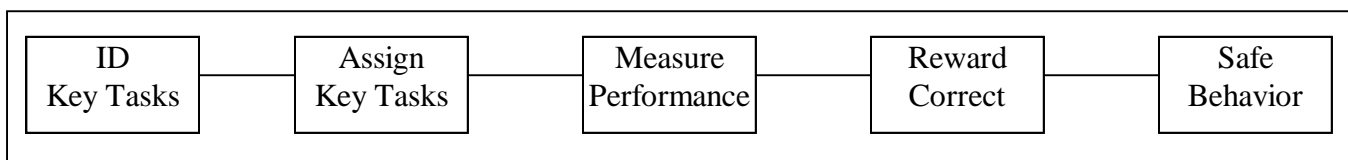
A5.6. Summary. It is not unusual for a risk control package to cost hundreds of thousands of dollars and even millions over time. Millions of dollars and critical missions may be at risk. The expenditure of several tens of thousands of dollars to get the decision right is sound management practice and good risk management.

Attachment 6

RISK CONTROL IMPLEMENTATION TOOLS AND DETAILS

A6.1. Introduction. Accountability is an essential element of risk management success. Organizations and individuals must be held accountable for the risk decisions and actions that they take. If they are not, there will be little motivation to achieve the degree of excellence in management of risk that the Air Force seeks. Good accountability and the resulting motivation it can create is not a matter of luck. Good accountability is created through the development of effective accountability systems and the delivery of focused rewards and corrective actions. The model depicted at Figure A6.1 is the basis of positive accountability and strong risk control behavior.

Figure A6.1. Implementation Model.



A6.2. Applying the model. The example below illustrates each step in the model applied to the sometimes difficult task of assuring that personnel consistently wear and use their protective clothing and equipment. The steps of the model should be applied as follows.

A6.2.1. Identify key tasks. This step may seem obvious. However, it is critical to actually define the key tasks with enough accuracy that effective accountability is justified. For example, in our example regarding use of protective clothing and equipment, it is essential to identify exactly when the use of such items is required. Is it when I enter the door of a work area? When I approach a machine? How close? What about on the loading dock? Exactly what items are to be worn? Is there any specific way that they should be worn? I can be wearing ear plugs but incorrectly have them stuck in the outer ear, producing little or no noise reduction benefit. Does this meet the requirement? The task needs to be defined with sufficient precision that personnel know what is expected of them and that what is expected of them produces the risk control desired. It is also important that the task be made as simple, pleasant, and trouble free as possible. In this way we significantly increase the ease with which the rest of the process proceeds.

A6.2.2. Assign key tasks. Personnel need to know clearly what is expected of them especially if they are going to be held accountable for the task. This is normally not difficult. The task can be included in job descriptions, operating instructions, or in the task procedures contained in manuals. It can be very effectively be embedded in training. In less structured situations, it can be a clear verbal order or directive. It is important that the assignment of the task include the specifics of what is expected.

A6.2.3. Measure performance. The task needs to include at least a basic level of measurement. It is important to note that measurement does not need to include every time the behavior is displayed. It is often perfectly practical to sample performance only once in large number of actions, perhaps as few as one in several hundred actions as long as the sample is a random example of routine behavior. Often the only one who needs to do the measuring is the individual responsible for the behavior. In other situations, the

supervisor or an outside auditor may need to do the observing. Performance is compared to the standard, which should have been communicated to the responsible individual. This step of the process is the rigorous application of the old adage that “What is monitored (or measured) and checked gets done.”

A6.2.4. Reward correct behavior and correct inadequate behavior. The emphasis should clearly be on reinforcing correct behavior. Reinforcement means any action that increase the likelihood that the person will display the desired behavior again. It can be as informal as a pat on the back or as formal as a major award or cash incentive. Correcting inadequate behavior should be done whenever inadequate behavior is observed. The special case of *punishment* should only be used when all other means of producing the desired behavior have failed

A6.2.5. Risk control performance. If the steps outlined above have been accomplished correctly, the result will be consistent success in controlling risk. Note that the extent of the rewards and corrective actions required will be dictated in part by the degree of difficulty and unpleasantness of the task. The harder the task for whatever reason, the more powerful the rewards and corrective actions needed will be. It is important to make risk control tasks as uncomplicated, and pleasant as possible.

Attachment 7

SUPERVISE AND REVIEW DETAILS AND EXAMPLES

A7.1. Introduction. Management is moving a task or an organization toward a goal. To move toward a goal you must have three things. You must have a goal, you must know where you are in relation to that goal, and you must have a plan to reach it. An effective set of risk matrices provides two of the elements.

A7.2. In regard to ORM, indicators should provide information concerning the success or lack of success of controls intended to mitigate a risk. These indicators could focus on those key areas identified during the assessment as being critical to minimizing a serious risk area. Additionally, matrices may be developed to generically identify operations/areas where ORM efforts are needed.

A7.3. Let's look at a representative set of risk measures that a maintenance shop leader could use to assess the progress of his shop toward the goal of improving safety performance. Similar indicators could be developed in the areas of environment, fire prevention, security, and other loss control areas.

A7.3.1. The tool control effectiveness index. Establish key indicators of tool control program effectiveness (percentage of tool checks completed, items found by QA, score on knowledge quiz regarding control procedures, etc.). All that is needed is a sampling of data in one or more of these areas. If more than one area is sampled, the scores can be weighted if desired and rolled up into a single tool control index by averaging them. See Figure A7.1 for the example.

Figure A7.1. Example Tool Control Effectiveness Measurement.

- a. The percent of tool checks completed is 94%.
- b. Items found by QA. Items were found in 2% of QA inspections (98% were to standard).
- c. Tool control quiz score is 88%.
- d. If all items are weighted equally ($94+98+88$ divided by $3 = 93.3$) then 93.3 is this quarter's tool control safety index. Of course, in this index, high scores are desirable.

A7.3.2. The protective clothing and equipment risk index. This index measures the effectiveness with which required protective clothing and equipment are being used by shop personnel. Data is collected by making spot observations periodically during the work day. Data are recorded on a check sheet and are rolled-up monthly. The index is the percent safe observations of the total number of observations made as illustrated at Figure A7.2.

Figure A7.2. Example Safety Observation Measurement.

TOTAL OBSERVATIONS: 27 SAFE OBSERVATIONS: 21

The protective clothing and equipment safety index is 78 (21 divided by $27 = 78\%$).
In this index high scores are desirable.

A7.3.3. The emergency procedures index. This index measures the readiness of the shop to respond to various emergencies such as fires, injuries, and hazmat releases. It is made up of a compilation of indicators as shown at Figure A7.3. A high score is desirable.

Figure A7.3. Example Emergency Procedures Measurement.

1. Scores on emergency procedure quizzes
2. Percentage of emergency equipment on hand and fully operational
3. Scores on emergency response drills indicating speed, correct procedures, and other effectiveness indicators.

A7.3.4. The quality assurance score. This score measures a defined set of maintenance indicators tailored to the particular type of aircraft serviced. Quality Assurance (QA) personnel record deviations in these target areas as a percentage of total observations made. The specific types of deviations are noted. The score is the percentage of positive observations with a high score being desirable. Secondary scores could be developed for each type of deviation if desired.

A7.3.5. The overall index. Any combination of the indicators previously mentioned, along with others as desired, can be rolled up into an overall index for the maintenance facility as illustrated at Figure A7.4.

Figure A7.4. Example Overall Measurement.

Tool control safety index:	93.3
Protective clothing and equipment safety index:	78.0
Emergency procedures index:	88.4
Quality Assurance Score:	97.9
TOTAL:	357.6
OR AVERAGE:	89.4

This index is the overall safety index for the maintenance facility. The goal is to push toward 100% or a maximum score of 400. This index would be used in our accountability procedures to measure performance and establish the basis for rewards or corrective action.

A7.4. Once the data has been collected and analyzed, the results need to be provided to the unit. With this information the unit will be able to concentrate their efforts on those areas where improvement would produce the greatest gain.

A7.5. Summary. It is not difficult to set up useful and effective measures of operational risk, particularly once the key risks have been identified during a risk assessment. Additionally, the workload associated with such indicators can be minimized by using data already collected and by collecting the data as an integrated routine aspect of operational processes.